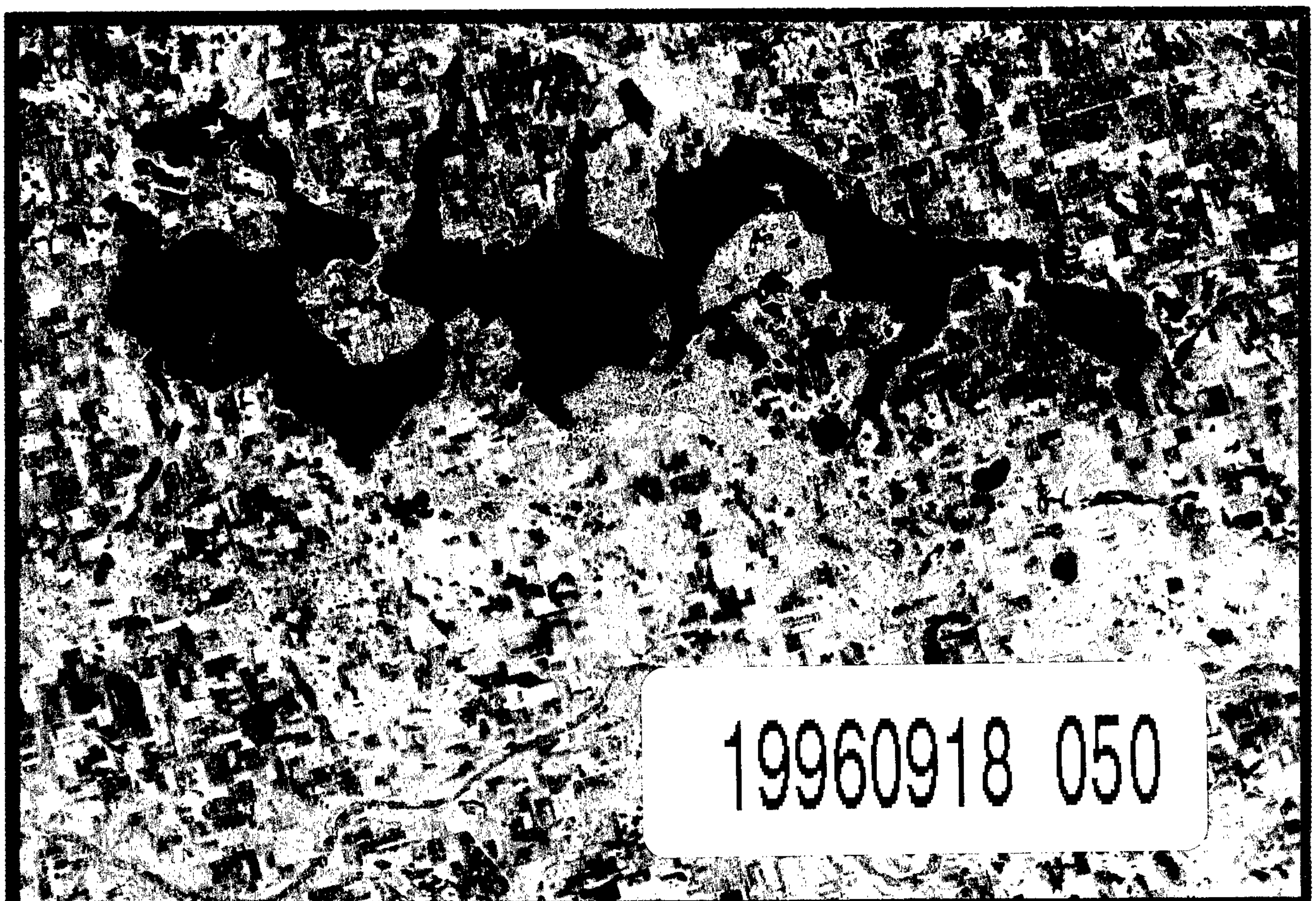
US Army Corps of Engineers
St. Paul District

Emergency Outlet Plan

Devils Lake, North Dakota



Devils Lake, North Dakota - 29 May 1996

12 August 1996

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DEVILS LAKE, NORTH DAKOTA
EMERGENCY OUTLET PLAN

EXECUTIVE SUMMARY

PURPOSE

1. The Devils Lake Emergency Outlet Plan (EOP) consolidates available information on a plan that could help reduce the Devils Lake flooding problem. The EOP examines engineering feasibility, effectiveness, and potential impacts. While the EOP lacks much field data to verify existing conditions and a full assessment of impacts, it will be a common reference point for discussions among interested parties regarding the practicability and implementability of an emergency outlet.

AUTHORITY

2. The EOP was prepared by the Corps of Engineers (COE) in response to a request from the North Dakota Congressional Delegation to the Assistant Secretary of the Army (Civil Works) at a 13 May 1996 meeting in Washington, D.C. The EOP is one part of a three-pronged response to the Devils Lake flood situation. The second part comprises short-term measures, including the Federal Emergency Management Agency (FEMA) Interagency Task Force Oversight Committee; State-led and Delegation-supported efforts to implement upper basin storage, an integral part of any overall basin water management plan; the Delegation-, State-, and locally-supported levee raise to protect the City of Devils Lake; flood insurance; and FEMA mitigation for relocations. The third part is the ongoing joint COE and North Dakota State Water Commission (NDSWC) Feasibility Study of long-term solutions to lake stabilization and other related concerns.

3. On 24 May 1996, Headquarters, U.S. Army Corps of Engineers (HQUSACE) issued guidance for preparation of the EOP outlining basic elements of the effort, i.e., an "... outlet plan ... based on existing information," with the candidate plan "selected from one of the 'Outlet to Sheyenne River' measures ... in the 15 February 1996 *Devils Lake, North Dakota Contingency Plan*." The EOP is to describe "major features; ... impacts; ... project effectiveness; ... necessary follow-on work and preliminary cost information; and assumptions."

OUTLET PLAN

4. The alternative presented in the EOP was identified from available information in the context of a number of criteria -- engineering feasibility, availability of information, relative effectiveness, views of the Spirit Lake Nation, costs, potential impacts, possible acceptability to downstream interests, compatibility with an inlet, and construction time. The candidate judged to offer the best balance among those criteria was a pumped-storage plan to move lake water over the divide between Devils Lake and the Sheyenne River via the Twin Lakes outlet route.

5. The plan involves pumping lake water up into a series of three pools created by earthfill dams; the pools act like a step ladder to successively raise the water up to the top of the divide. At that point, the water flows down to the Sheyenne in an open channel. An outlet capacity of 200 cubic feet per second (cfs) was used based on available information regarding the river's channel capacity and ambient water quality in the lake and river. This report also discusses the impacts on costs, effectiveness, and Sheyenne River water quality with larger capacities.

REAL ESTATE

6. The Twin Lakes outlet route lies entirely on Devils Lake Sioux Reservation lands, with three ownership types -- Tribal Trust, Indian-owned allotment tracts, and non-Indian private ownership tracts. These lands would require a coordinated effort between the non-Federal Sponsor, COE, and Bureau of Indian Affairs (BIA) to obtain the necessary real estate interests, approximately 80 acres of temporary easements during construction, 380 acres of permanent easements, and 10 acres of fee title.

EFFECTIVENESS

7. Effectiveness of the EOP was tested by simulating the October 1985 through September 1995 10-year period to compare the lake level with and without outlet operation. Outlet operation was restricted by the following: (1) a Devils Lake "trigger elevation" of 1428, above which pumping would be permitted; (2) a 200-cfs pumping capacity; (3) a May through November, 7-month operating "window," with operation suspended for the winter; (4) the Sheyenne River's 450 milligrams per liter (mg/l) sulfate standard for the combined river flow and outlet discharge; and (5) the Sheyenne River's estimated 500-cfs bank-full channel capacity.

8. The analysis showed that, through 1994, outlet operation would have been constrained largely by the sulfate standard because of the lake's high salinity. By 1995, the rising lake was diluted to the point where bank-full and pumping capacities would have been the constraining factors. The results showed that the without-project lake elevation of 1435.09 at the end of September 1995 would have been reduced 1.09 feet.

SENSITIVITY

9. The COE analyzed the sensitivity of results to larger pumping and Sheyenne River bank-full capacities. For example, the lake elevation would have been reduced 1.44 feet with a 300-cfs discharge capacity and 600-cfs bank-full capacity. The COE also conducted a sensitivity test assuming the outlet tapped fresher water entering the lake. This scenario produced lake elevation reductions ranging from 1.56 to 2.13 feet over a 10-year period.

OTHER PROPOSALS

10. Other suggestions for addressing Devils Lake flooding are discussed, including (1) upper basin storage, which the NDSWC is developing and the North Dakota Congressional Delegation is supporting in conjunction with other Federal, State, and local agencies, (2) tapping Big Coulee inflows as discussed in paragraph 9 and discharging them to the Sheyenne River via either the Twin Lakes or Peterson Coulee outlet routes, and (3) treating the saline lake water to improve outlet operation and acceptability to downstream interests.

WATER QUALITY EFFECTS

11. Outlet discharges from the 10-year simulation for the effectiveness analysis were routed down the Sheyenne River and Red River of the North to assess the resulting downstream water quality impacts at several locations -- Warwick, Cooperstown, Baldhill Dam/Valley City, Lisbon, Kindred, and West Fargo on the Sheyenne River and Halstad, Grand Forks, and Emerson on the Red River of the North.

12. In the upper Sheyenne River, outlet operation produced abrupt changes in sulfate concentrations. When the 450 mg/l standard was reached at the insertion point, downstream sulfate levels were below the standard because fresher local and tributary inflows dilute the river flow. Lake Ashtabula's storage

greatly attenuated peak sulfate levels and stretched the duration of elevated sulfate levels for the lower Sheyenne River. The resulting impact on Lake Ashtabula must be assessed.

13. The Red River of the North's flow further diluted sulfate concentrations below its confluence with the Sheyenne River, and at no time during the 10-year simulation was the 250 mg/l Red River sulfate standard and International Border objective exceeded. However, outlet operation will also raise Total Dissolved Solids (TDS) levels along the Sheyenne and Red Rivers. Although the Sheyenne River has no TDS standard, the Red River standard and International Border objective of 500 mg/l TDS is already exceeded under without-project conditions; consequently, outlet operation could increase the frequency, duration, and magnitude of those occurrences.

ENVIRONMENTAL EFFECTS

14. Construction and operation of the emergency outlet would affect an estimated 970 acres of wetlands, woods, and grasslands along the Twin Lakes outlet route. The EOP discusses the potential natural resources effects and corresponding mitigation needs. There are no sites along the outlet route known to be listed on or eligible for the National Register of Historic Places. However, most of the outlet route has not been surveyed for cultural resources, nor has the outlet route been inventoried for traditional cultural properties.

15. Environmental effects to Devils Lake and along the Sheyenne River from outlet operation were not assessed at this time. The EOP identifies required studies and proposes an extensive monitoring program to address areas of concern related to changes in downstream water quality and quantity, including impacts on natural and cultural resources, bank erosion, municipal water supply, etc.

COST ESTIMATE

16. Estimates of first costs and operation and maintenance costs were made for a diesel-powered, 200-cfs design capacity outlet. The $21,000,000 estimated first costs include planning, engineering, design, construction management, real estate, quantifiable environmental mitigation, and construction. Annual operation and maintenance costs are estimated at about $700,000 when the project is operating 7 months per year (with operation suspended for the winter) and about $200,000 per year when the project is not pumping.

IMPLEMENTATION

17. Two implementation scenarios are described, a 60-month timeline assuming that activities are accelerated but normal project criteria would be satisfied, including preparation of an up-front Environmental Impact Statement (EIS), preparation of design documents, standard real estate acquisition and contracting procedures, and a 2-year construction schedule following timely Congressional authorization and appropriations.

18. A 29-month schedule, which assumes specific Congressional emergency authorization and appropriations, is also discussed. Such an emergency would require waiving policy requirements, e.g., for the planning and design process, real estate actions, and contracting procedures. In addition, National Environmental Policy Act (NEPA) requirements would have to be modified. Construction under this scenario would likely cost more than with the 60-month scenario.

19. Both timelines depend on close cooperation between Federal and State agencies, the Spirit Lake Nation, and other local interests; timely authority and funding; no real estate delays; and no litigation.

INTRODUCTION/AUTHORITY

20. The Devils Lake EOP was prepared by the COE in response to a request from the North Dakota Congressional Delegation to H. Martin Lancaster (Assistant Secretary of the Army (Civil Works)), at a 13 May 1996 meeting in the offices of Senator Byron Dorgan attended by Senator Kent Conrad, Representative Earl Pomeroy, James Lee Witt (Director of FEMA), and staff members from the offices of the ND Delegation, ASA(CW), FEMA, and HQUSACE.

21. The EOP is part of a three-pronged response to the Devils Lake flood situation. The EOP is intended to meet near-term needs with an emergency outlet plan that examines engineering feasibility, effectiveness, and potential impacts, so that all concerned interests have a common reference. The EOP is expected to serve as a focus of discussions among decision-makers regarding the practicability of an emergency outlet.

22. The other two parts of the three-pronged response are:

a. Short-term measures including (1) coordination of Federal, State, and local efforts through the FEMA Devils Lake Interagency Task Force Oversight Committee; (2) the COE-designed levee raise to protect the City of Devils Lake under the Advance Measures provision of Public Law 84-99; (3) flood insurance; (4) FEMA mitigation for relocations; and (5) State- and Delegation-led efforts to promote and implement upper basin storage, which is considered an integral component of an overall solution to Devils Lake's problems, particularly a solution involving release of Devils Lake water outside the basin.

b. Long-term solutions to basin water-related problems through the joint COE and NDSWC Feasibility Study which is addressing the areas of concern spelled out in Public Law 102-377, i.e., lake stabilization, basin water management, fish and wildlife, recreation, and water quality.

23. On 24 May 1996, HQUSACE issued guidance directing the North Central Division, COE, to prepare the EOP. This directive, in turn, was forwarded to the St. Paul District, COE, for action. Key points in the guidance which define the EOP effort include:

- Goals
  - Develop technically feasible plan within 90 days
  - Select outlet from plans listed in the *Devils Lake Contingency Plan*
  - Base plan on existing information
- End-product
  - Show major features
  - Identify impacts
  - Describe effectiveness
  - Develop preliminary cost estimates
  - Discuss assumptions made for EOP effort
  - Show a schedule for follow-on work needed for implementation
- Budget
  - Use Feasibility Study funds
  - Amend the Feasibility Cost Sharing Agreement (FCSA)

24. On 8 October 1993, the COE and NDSWC entered into an FCSA for a comprehensive Feasibility Study of Devils Lake stabilization, basin water management, recreation, fish and wildlife, and water quality as specified in Public

Law 102-377. Under the FCSA, the COE and NDSWC share study costs equally. In accordance with the HQUSACE EOP guidance, on 11 June 1996, the St. Paul District sent Amendments for the FCSA to the State Engineer covering the EOP and adjusting the schedule of ongoing Feasibility Study efforts to accommodate the funding and manpower commitment to the EOP.

OUTLET PLAN

GENERAL

25. The EOP was selected from outlet alternatives listed in the *Devils Lake Contingency Plan*. Those alternatives had survived a screening of outlet options during the 1995 interagency, collaborative process to develop a concept-level Plan of Study for the Devils Lake Feasibility Study. During that process, a qualitative and quantitative assessment of outlet options narrowed the list of practicable routes down to Peterson Coulee and Twin Lakes (Figure 1). The *Contingency Plan* took the next step and considered ways of getting Devils Lake water to the Sheyenne River (e.g., over the divide between the lake and river via pumped storage (raised lakes) or pipelines versus through the divide via gravity-flow channels) and presented preliminary cost estimates and general impacts for those alternatives.

26. Selection of an outlet plan for the EOP effort was based on an assessment of available information vis-a-vis criteria judged important in development of an engineeringly feasible and implementable plan, including engineering feasibility, availability of information, relative effectiveness, views of the Spirit Lake Nation, costs, potential impacts, acceptability to downstream interests, compatibility with an inlet, and construction time. Those criteria are discussed further in the OUTLET SELECTION CRITERIA APPENDIX.

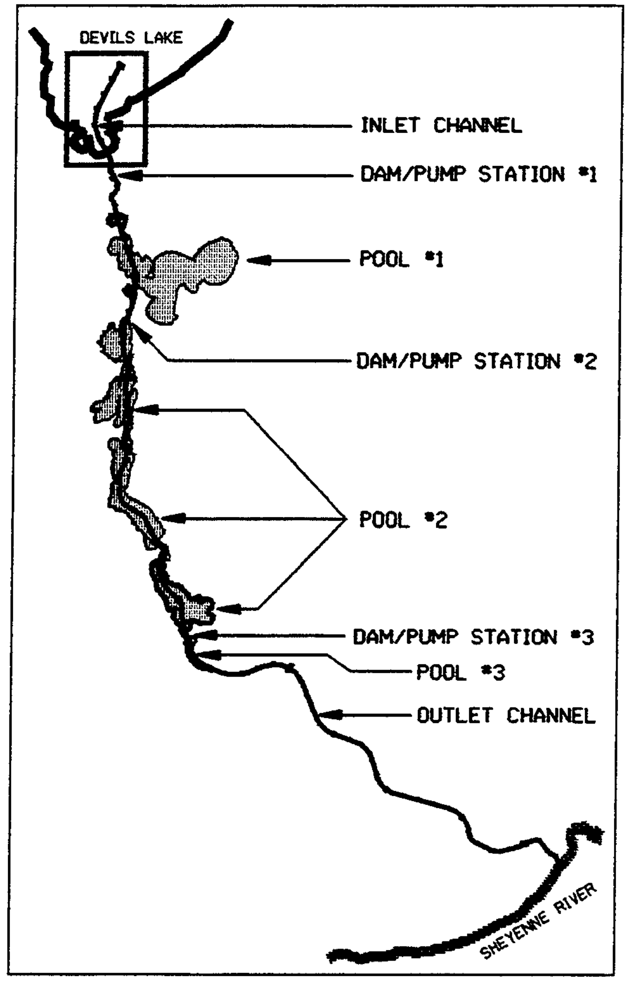
27. The plan judged to be the best balance between those criteria was a pumped-storage plan to move lake water over the divide via the Twin Lakes route. This plan takes advantage of the natural topography along the Twin Lakes route, including an existing chain of lakes between Devils Lake and the divide, and a coulee from the divide to the Sheyenne River. Basically, this plan involves pumping lake water up into a series of three pools created by earthfill dams; the pools act like a step ladder to successively raise the water up to the top of the divide, which is about 60 feet above the current lake level. At that point, the water flows down to the Sheyenne in an open channel, with a series of drop structures to absorb the energy of the flowing water. The project would be nearly 13 miles long. An outlet capacity of 200 cfs was used based on available information regarding the river's channel capacity and ambient water quality in the lake and river.

28. Available topographical, geological, and technical data was supplemented by engineering judgment to develop the EOP, the major features of which are shown on Figures 2 and 3. Certain features (e.g., pump stations) were adapted from other COE projects to fit the Devils Lake situation. Before any feature is considered for actual construction, all appropriate field work, sampling, lab testing, engineering analyses, and design work must be done.

29. Operation is assumed to be limited to a 7-month "window" from 1 May through 30 November to prevent pump damage from ingested ice and to avoid adding flow to the river during spring runoff in the lower Sheyenne River. Within that "window," operation would be restricted by (a) the Sheyenne River's estimated 500-cfs channel capacity in the vicinity of the outlet confluence and (b) the State's 450-mg/l sulfate standard for the river. Operation would also be suspended when any portion of the Sheyenne River was threatened by high stages.

INTAKE CHANNEL (Project Sta. 0+00 - 73+00)[1]

30. The outlet would start with a 7,300-foot open channel (Figure 4) from Devils Lake (which is currently at an elevation of about 1437.7) to Dam/Pump Station #1. Channel dimensions include side slopes of 1-vertical-on-5-horizontal (1:5), a bottom width of 10 feet, and a bottom elevation of 1423.5 to allow continued operation as the lake elevation drops.



31. The amount of "wet" and "dry" construction will be sensitive to changes in lake elevation because of the shallow slope of this shoreline. At a lake elevation of 1440, about 6,300 feet of the channel alignment would be under water. This reach could be built by constructing a temporary causeway for equipment access to shallower areas and using barge-mounted excavation equipment for deeper areas; alternatively, barge-mounted equipment could be used for the entire reach. The alignment's remaining 1,000± feet would be on land; however, site-specific conditions are unknown, and this portion might also require "wet" construction techniques. The groundwater level probably mirrors Devils Lake's elevation, in which case, much of the excavated material will come from below the water table, requiring sand drains or dewatering wells to prevent slumping of the channel sides.

DAMS

32. The three dams and pump stations are basically identical (Figure 5). The base of each dam is "keyed into" the foundation material for stability and to ensure good seepage control. It was assumed that satisfactory embankment materials could be found in adjacent sources. The dams each have an impervious core, a pervious (sand) drain to carry off seepage, a 20-foot top width, and 1:2.5 side slopes of random fill riprapped on both upstream and downstream faces to prevent erosion from wave action. Distinguishing features include the following:

a. Dam #1 (Sta. 73+67), Dam #2 (Sta. 165+57), and Dam #3 (Sta. 375+45) have top lengths of about 287, 424, and 513 feet, respectively. Dams #1 and #3 have 5 feet of freeboard above their pool elevations of 1450 and 1495, respectively. Freeboard is provided to protect against overtopping by waves and unanticipated foundation settlement. Dam #2 has 7 feet of freeboard because this dam includes an emergency spillway at elevation 1470 to prevent

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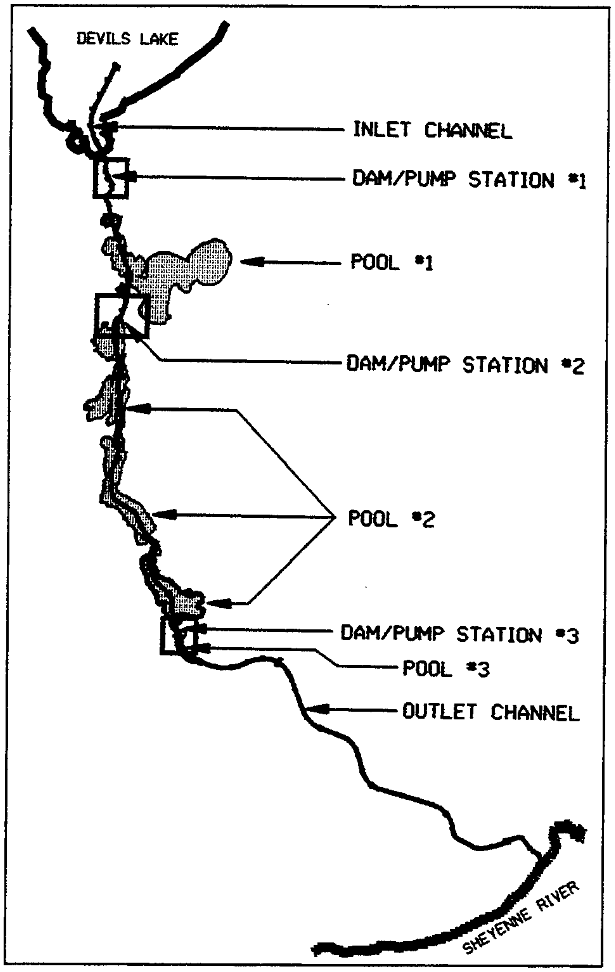
[1] Project stationing is in terms of 100 feet, i.e., Station 37+50 is 3,750 feet from the starting point.



catastrophic failure of the embankment from overtopping should a major local runoff event coincide with full pool during outlet operation. Emergency spillways were not provided for Dams #1 or #3 because: (1) There is nothing between Dam #1 and Devils Lake or Dam #3 and Pool #2 to be damaged by a sudden release of water. (2) The volumes of Pools #1 and #3 are minor relative to Devils Lake and Pool #2, respectively; if failure did occur, the resulting bounce of Devils Lake or Pool #2 would not pose a danger. A reinforced concrete emergency spillway was provided for Dam #2 because: (1) The drainage area of Pool #2 is substantially larger than those of Pools #1 and #3; therefore, Pool #2 has a higher risk of a major local runoff event. (2) Pool #2 has a large volume relative to Pool #1; therefore, the bounce resulting from a catastrophic failure of Dam #2 might pose a threat to residences around Twin Lakes (Pool #1) and/or cause a domino-type failure of Dam #1.

b. Dams #2 and #3 are sited in areas with sand and gravel foundation materials; therefore, their designs include slurry-type cutoff trenches to control subsurface seepage. Dam #1, in an area with impervious foundation material, does not need a cutoff trench.

PUMP STATIONS

33. The pump stations (Figures 5 and 6) would be basically identical for ease in design and contracting and cost savings from duplicate pumps, motors, etc. Each pump station would be a pre-engineered metal superstructure on a concrete substructure/wetwell set on 40-foot timber piles.

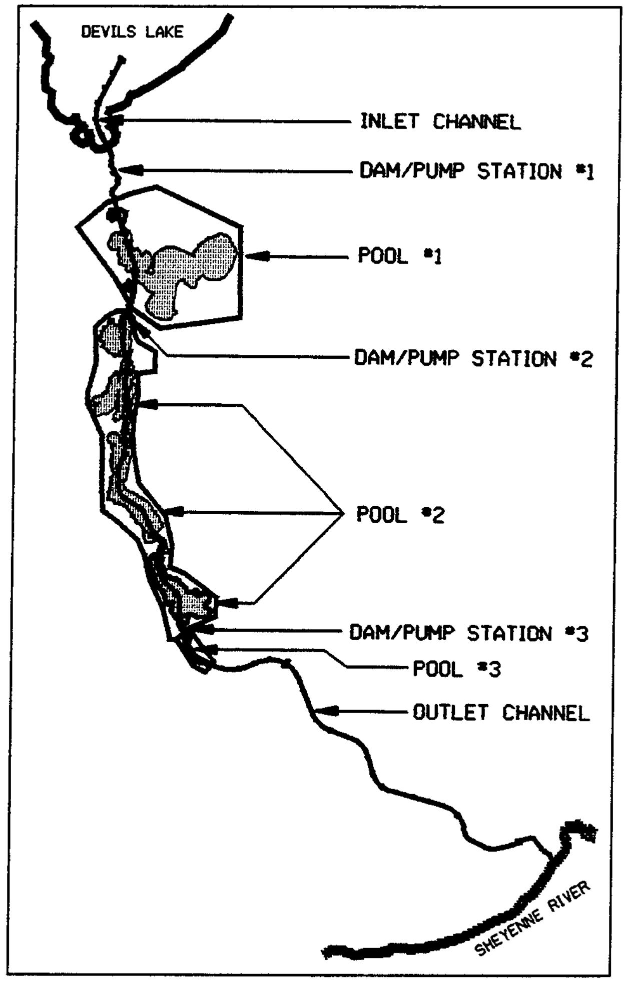
a. The EOP used a 200-cfs rating for each pump station; however, the pump station design could accommodate larger pumps with no changes to the basic structure. Pump Stations #1 and #2 would use single-stage vertical propeller pumps to handle static heads of 20 and 21 feet, respectively, plus headlosses from friction, etc.; Pump Station #3 would use double-stage vertical propeller pumps to deal with 25 feet of static head plus headlosses.

b. The four pumps in each station would be powered by four 8-cylinder, 200-hp diesel motors (225-hp at Pump Station #3 due to the higher head). Pipeline would be 30-inch diameter. Electrical service (100-amp) would be provided for lights, ventilators, instrumentation, etc.

POOLS

34. Figure 7 shows a typical cross section for channel segments between Dams/Pump Stations #1 and #2. Excavation in this reach will include areas

that need dewatering where work is within the natural channel or below the water table.



35. Figure 8 depicts with- and without-project views of the intake channel, Dam/Pump Station #1, and the Pool #1 channel segment north of Highway 57. Figure 9 shows with- and without-project views of Dam/ Pump Station #2 with Pool #1 in the foreground and Pool #2 in the background. Figure 10 shows with- and without-project views of Dam/Pump Station #3 with Pool #2 to the right and Pool #3 to the left.

36. There is no information regarding ordinary high water marks for Twin Lakes or the chain of five unnamed lakes and wetlands to its south shown on the USGS Crow Hill quadrangle map issued in 1951 and photo-revised in 1975. The quad map shows elevations for just two lakes, Twin Lakes at 1447 and the southernmost (fifth) unnamed lake at 1467. Based on a site visit in June 1996, the lakes were estimated to currently be at the following elevations: Twin Lakes 1455, unnamed lake 1 - 1457, unnamed lake 2 - 1458, unnamed lakes 3 and 4 (joined) - 1462, unnamed lake 5 - 1475.

37. Pool #1's (Sta. 74+00 - 164+50) proposed 1450 elevation would lower Twin Lakes from its current elevation, which has flooded adjacent fields and converted what are shown as wetlands on the Crow Hill quad map to open water.

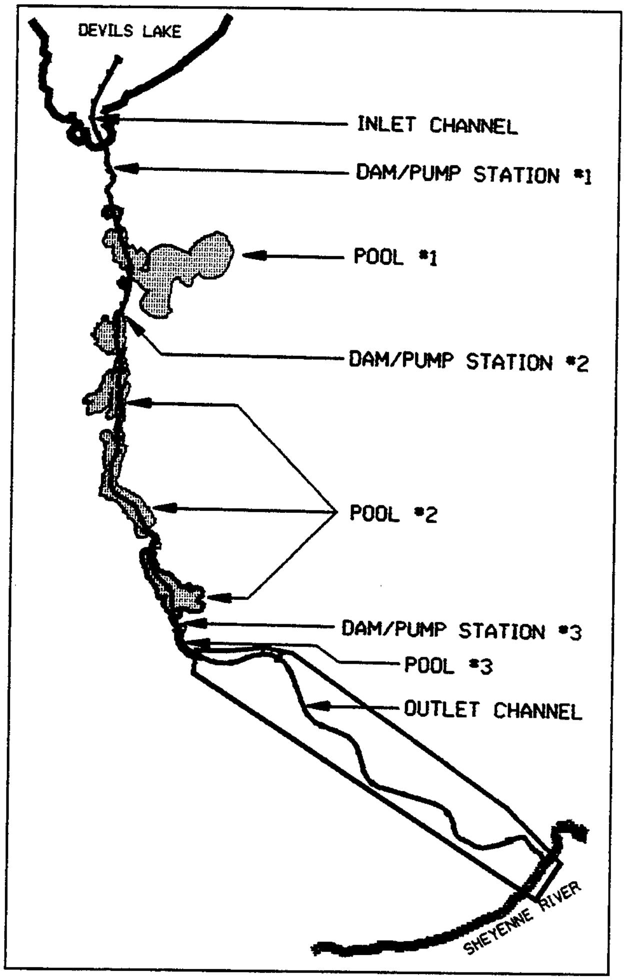
38. Pool #2's (Sta. 165+90 - 374+35) proposed 1470 elevation would join unnamed lakes 1 - 5 (with some minor channel work between lakes 4 and 5). Unnamed lakes 1 - 4 would be raised an estimated 8 to 13 feet; lake 5 would be lowered an estimated 5 feet from its current level.

39. Pool #3's (Sta. 375+75 - 401+50) small (12-acre) impoundment at its proposed 1495 elevation would basically serve as a booster to allow water to flow over the divide to the Sheyenne River.

OUTLET CHANNEL (Sta. 401+50 - 678+90)

40. The existing coulee from the top of the divide to the Sheyenne River is fairly steep, particularly at its downstream end where it drops down to the river; however, heavy vegetation and a series of wetlands along its length slow natural runoff and curtail erosion.

41. The outlet channel would be designed to add the outlet's maximum 200 cfs to normal coulee flows without inducing erosion problems. A channel approximately 4 feet deep with a bottom width of 30 feet and 1:4 side slopes would be incised into the coulee bottom to keep the 200-cfs outlet flow within the banks and minimize impacts on adjacent wetlands (Figure 11). A local runoff



event coinciding with outlet operation at full capacity would cause the combined flow to overtop the channel and flow over the coulee's floodplain, more or less replicating natural conditions. When the outlet is not operating, a local runoff event with a flow less than 200 cfs would stay within the outlet channel; flows exceeding 200 cfs would break out into the adjacent floodplain.

42. During construction, the existing stream would be rerouted. In wet reaches, excavation will start at the downstream (Sheyenne River) end to allow natural drainage to minimize work in the wet and dewatering expenses.

43. The channel slope must be relatively flat to keep flow velocities low enough to avoid the need for riprap- or concrete-lining to prevent erosion. This would be achieved by placing nineteen 3-foot drop structures at strategic points between reaches of flatter slope to "step" the water down to the river. The drop structures (Figure 12) would be built with gabions to take advantage of their inherent flexibility, which allows them to adjust to settlement. The gabions (rectangular, compartmented, stone-filled baskets) would be placed on geotextile fabric to separate the gabions from the underlying fine foundation materials.

ROADS

44. The outlet alignment crosses eight roads according to the USGS Crow Hill quadrangle map. The EOP proposes to treat those roads as follows (see corresponding numbers on accompanying figure):

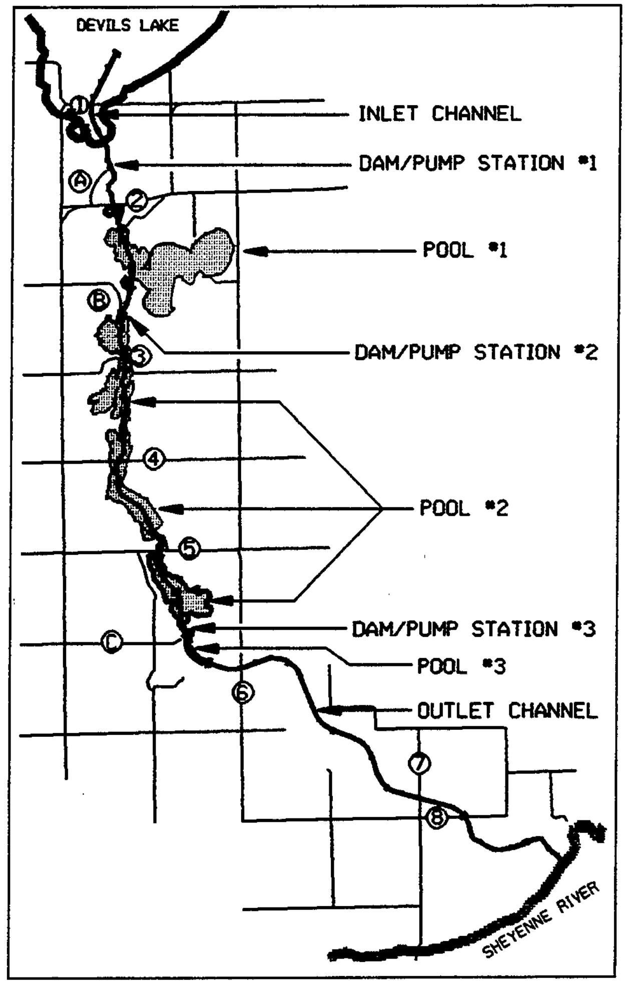
Project Sta.		Description	Proposal
(1)	34+50	Section line road	Abandon -- already under water; previously abandoned
(2)	98+50	Highway 57	Retain; install 10x10 box culvert
(3)	194+00	Section line/Township road	Raise; install 10x10 box culvert
(4)	257+00	Section line/farmstead access road	Abandon -- currently unused
(5)	321+50	Section line/Plainview School No. 2/County road	Retain; install 10x10 box culvert
(6)	421+00	Section line/field road	Abandon -- currently unused
(7)	571+50	Section line/Township road	Retain; install 10x10 box culvert
(8)	601+00	Section line/Township road	Retain; install 10x10 box culvert

45. New single-lane, gravel-surfaced roads must be built to provide access for construction, maintenance, and diesel fuel delivery for the dams/pump stations. Cross section, alignment, etc. were not developed during the EOP effort; these details could be added when site-specific information (e.g., detailed survey data and foundation conditions) becomes available. General unit cost data were used to estimate the costs of the following access roads (see corresponding letters on accompanying figure):

(a) Dam/Pump Station #1 -- Approximately ½ mile long; north from Highway 57 generally following the east-west mid-point of Lallie Township sections 16 and 21.

(b) Dam/Pump Station #2 -- Approximately 1 mile long; east ½ mile from Highway 281 along an existing field road on section line 21/28 Lallie Township, then south-east ¼+ mile to the dam/pump station site.

(c) Dam/Pump Station #3 -- Approximately 1½ miles long; east from Highway 281 generally along section line 9/16 Rock Township.



REAL ESTATE

46. The non-Federal Sponsor for the project (likely the NDSWC) would be responsible for providing lands, easements, rights-of-way, relocations, and disposal sites (LERRDs). As shown on Figure 13, the outlet alignment lies entirely on Devils Lake Sioux Reservation lands and crosses a checkerboard of three ownership types -- land held in Tribal Trust, individually-owned Indian allotment tracts, and private ownership tracts ("fee lands" on the map) -- which would add to the complexity of real estate acquisition and might require COE involvement.

47. Tribal lands within Reservations are created by treaty or Presidential Executive Order, with fee ownership remaining with the Federal Government subject to a Trust relationship between the Government and tribe. Conveyance of easements would require Tribal Council, BIA, and Secretary of the Interior approval. Conveyance of fee ownership or condemnation of Tribal lands would be initiated by the COE and would require specific Congressional approval.

48. The General Allotment Act encouraged individual tribal members to occupy tracts of public domain or Reservation land. "Patents" issued for those tracts retained fee title for the Government subject to Trust provisions. Allotment tracts will require that the Sponsor coordinate with the BIA for making offers and closings on interests up to and including fee acquisition. If condemnation was necessary, the COE would complete those acquisitions.

49. Private ownership tracts could be handled in a routine manner by the Sponsor. If the Sponsor could not reach a negotiated agreement with an owner, the Sponsor could exercise its power of eminent domain and condemn the parcel with payment of just compensation.

50. Real estate interests required for this project include approximately 7½ acres of fee title for the dam/pump station sites, 379 acres of permanent easements (85 acres of channel easements, e.g., along the intake and outlet channels; 270 acres of flowage easements for lands around Twin Lakes and the chain of unnamed lakes inundated during operation; and 24 acres of access easements, e.g., for the access roads), and 76 acres of temporary work area easements (during construction).

51. For more details, see the REAL ESTATE APPENDIX.

EFFECTIVENESS

GENERAL

52. Effectiveness of the EOP was tested by using a simulation of the 10-year period October 1985 through September 1995[2] to compare the lake level with and without outlet operation. Outlet operation was assumed to start when the lake exceeded a "trigger elevation" of 1428 and cease when the lake fell to 1428 once again. This 10-year interval included two periods when the lake exceeded 1428 -- in 1987 and from 1994 to the present.

53. A trigger elevation is necessary because an outlet could not release water from the lake as fast as it enters due to channel capacity and water quality constraints in the Sheyenne River.[3] Therefore, even with the outlet operating at full capacity, the lake would "bounce" in response to inflow events. The goal of a trigger elevation is to start pump-out before the lake is at a threatening elevation and to draw the lake down to a nonthreatening elevation after the event is over.

54. The Feasibility Study will address alternative trigger elevations, which must balance a variety of (in some cases, conflicting) interests. For example, current high lake levels have caused millions of dollars of damage to the transportation system, lakeshore homes, utilities, etc., but have benefited the lake's fishery and recreational industry.

55. Prior discussions between Federal, State, and local officials suggest that a reasonable operating range would be between 1425 and 1435. One consideration is that outlet operation carries a risk of worsening future low-level situations. For example, removal of 1 foot off the lake's current 1437.7± is equivalent to about 78,000 acre-feet (ac-ft). Loss of that volume of water would have put the lake nearly 1.8 feet below its 1993 recent low of 1422.5±, when concerns were being expressed about the survival of the fishery.

56. Consequently, the outlet should not be operated unless a serious flood threat is developing. Unfortunately, lake behavior is not predictable. Analysis of output from the USGS lake level-probability model shows that

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[2] The latter corresponds to published river flow data, which was not available for the period October 1995 to the present.

[3] For example, at its current elevation of 1437.7±, a 1-day 1-inch rainfall on the lake is equivalent to an inflow of over 3,000 cfs, 15 times the EOP's 200-cfs design capacity. Big Coulee and Channel A inflows also exceeded 3,000 cfs in the spring of 1995.

decisions to start outlet operation are more likely to prove correct with a higher trigger elevation. However, as shown by the lake's recent surge, deferring the decision until the lake rises may result in damaging levels. In the absence of the more detailed analyses to be done as part of the Feasibility Study, the COE determined that a trigger elevation of 1428 was a reasonable figure to use for the EOP's effectiveness assessment.

57. Outlet operation was assumed to be limited to a 7-month "window" -- 1 May through 30 November. Operation would be shut down from 1 December to 30 April (a) to prevent pump damage from ingested ice and (b) to avoid adding flow to the river during spring runoff in the lower Sheyenne River.[4] Operation was also constrained by (a) the Sheyenne River's estimated 500-cfs bank-full capacity in the vicinity of the outlet confluence and (b) the river's 450-mg/l sulfate standard.

58. The lake was at 1435.09 on 30 September 1995; with outlet operation, the lake would have been at 1434.00, 1.09 feet lower. The outlet would have reduced the 1995 peak elevation of 1435.89 on 28 July 1995 to 1435.01 on 15-18 July 1995.

59. The effect of the river's sulfate standard is illustrated in the following table of average monthly data for 1987, 1994, and 1995. The table shows that the 450 mg/l standard would have constrained outlet operation most of the time, particularly in 1987 and 1994.

60. In 1987, the high sulfate level in the lake (1300+ mg/l) would have reduced the allowable outlet discharge to just one-third (or less) of the river's flow. The outlet would have averaged only 12 cfs during 168 days of operation. By 1994, the sulfate concentration in the rising lake had fallen to 670± mg/l, and a given river flow could handle outlet water on greater than a one-for-one basis, which increased the average pumping rate to 70 cfs over the entire 214-day/7-month "window." In 1995, the sulfate concentration in the lake was below the river's 450-mg/l standard through July, which removed water quality as the constraining factor during that period; instead, operation was limited by the bank-full capacity or 200-cfs peak pumping capacity. As a result, the average outlet rate increased to 156 cfs over 153 days (the 5-month period for which 1995 hydrologic data were available).

61. Figure 14 shows a sample cross section of the Sheyenne River near the river's confluence with the Twin Lakes outlet. The figure compares actual river flows on two dates to the combined (river plus outlet) flow under two outlet conditions -- (a) a May 1995 case when high river flow caused the outlet discharge to be limited by the river's bank-full capacity at the outlet confluence, and (b) an August 1995 case when the outlet discharge was limited by the sulfate standard. Figure 15 illustrates the corresponding conditions at a cross section below Valley City, ND, where channel capacity is substantially greater than in the upper Sheyenne. The delayed dates reflect estimated travel time for outlet flow to reach Valley City.

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[4] Flow at the confluence of the outlet and upper Sheyenne River could be well below bank-full (theoretically allowing operation of the outlet), even though the lower Sheyenne River could be at high stages from spring runoff. Therefore, outlet operation was assumed suspended during the March-April spring runoff period for the lower basin. In addition, the operating plan would direct that operation be interrupted any time that high water anywhere along the river posed a potential flood threat.

MONTH	FLOW (cfs)			SULFATE (mg/l)		
	SHEYENNE RIVER	OUTLET[a]	COMBINED	SHEYENNE RIVER	OUTLET	COMBINED
1987[b]						
May	45	15	60	154	1315	450
June	16	6	22	128	1363	450
July	89	21	110	73	1515	425
August	51	17	68	95	1584	450
September	14	4	18	135	1694	450
October	15	4	19	128	1779	450
1994[c]						
May	67	79	146	164	671	445
June	139	145	284	145	670	426
July	45	67	112	121	671	450
August	9	13	22	136	671	450
September	10	14	24	134	672	450
October	42	70	112	111	663	450
November	56	101	157	130	627	450
1995						
May	240	196	436	184	403	285
June	78	200	278	192	408	351
July	75	200	275	182	420	356
August	45	155	200	215	478	422
September	10	25	35	209	557	450

[a] Average pumping rate while pumping, excluding "downtime."
[b] The lake level exceeded the trigger elevation (1428) on 27 April 1987; the pumping "window" started 1 May 1987. With the project in operation, the lake would have fallen below 1428 on 18 October 1987.
[c] The lake level exceeded 1428 on 17 March 1994; the pumping "window" started 1 May 1987.

SENSITIVITY

62. The same 10-year simulation period was used to examine the sensitivity of results to two variables -- the Sheyenne River's estimated bank-full capacity and the outlet's design peak pumping capacity. In addition to the original set of parameters -- a 500-cfs bank-full capacity and 200-cfs pumping capacity -- the sensitivity tests included a 600-cfs bank-full capacity, a 300-cfs design peak outlet capacity, and 458- and 557-cfs "maximum" outlet capacities (the largest calculated discharges during the 10-year simulation if outlet

capacity was limited only by the 450-mg/l sulfate standard and 500- and 600-cfs bank-full capacities, respectively).

63. The results, shown in the table below, compare the with-project lake elevation on 30 September 1995 to the without-project elevation of 1435.09. For example, as noted earlier, the 500-cfs bank-full capacity and 200-cfs peak design outlet capacity yielded a computed drawdown of 1.09 feet. In comparison, a 600-cfs bank-full capacity and 557-cfs maximum discharge capacity produced a 1.97-foot drawdown.

BANK-FULL CAPACITY (cfs)	OUTLET PEAK CAPACITY (cfs)	DEVILS LAKE ELEVATION	ELEVATION REDUCTION (ft)	VOLUME PUMPED (ac-ft)	OUTLET OPERATION (days)	AVERAGE OUTLET RATE (cfs)
500	200	1434.00	1.09	81,000	535	76
500	300	1433.71	1.38	100,000	535	94
500	458[a]	1433.44	1.65	119,000	535	112
600	200	1433.98	1.11	82,000	536	77
600	300	1433.65	1.44	105,000	536	99
600	557[a]	1433.12	1.97	142,000	536	134

[a] Maximum discharge rate recorded during the 10-year simulation.

64. Figure 16 shows daily lake elevations during the entire 10-year simulation period with and without project operation for the EOP's 200-cfs outlet design peak pumping capacity and a 500-cfs bank-full capacity. Figure 17 expands the with- and without-project data for the 1994-1995 portion of the simulation period for greater clarity. Figure 18 shows how elevation reduction varies with design pump capacity for the 500- and 600-cfs bank-full capacities used in the sensitivity tests.

65. The COE also conducted sensitivity tests to assess the efficacy of an outlet tapping a fresher source of discharge water. These tests used the same constraints -- a trigger elevation of 1428, 200-cfs peak pumping capacity, 7-month pumping "window," 500-cfs bank-full capacity in the river, and 450-mg/l sulfate standard in the river. Scenario A assumed that Big Coulee water could be pumped to the Sheyenne River before mixing with Devils Lake water. Because the sulfate concentration in coulee water is below the river's sulfate standard, coulee water could be pumped without running into the water quality constraint until either the design pumping capacity or bank-full capacity was reached, with excess coulee inflow bypassed into the West Bay. This scenario produced a with-project lake elevation on 30 September 1995 of 1433.53, a drawdown of 1.56 feet from the without-project figure.

66. Scenario B assumed that, when coulee inflows decreased to the point that there was additional pumping or bank-full capacity, West Bay water could be added to the outlet flow until the total discharge matched the design peak pumping capacity or until the mix of coulee, West Bay, and river water reached either the 500-cfs bank-full capacity or 450-mg/l sulfate standard. This

scenario would increase the drawdown to a calculated 2.13 feet. The estimated 0.57 foot of additional drawdown (above that achieved tapping Big Coulee's inflows alone) is on the high side, because the initial draw-off of fresher coulee inflows would cause West Bay waters to be somewhat more saline than the data used in the analysis. Figure 19 shows daily lake elevations during the entire 10-year simulation period with and without project operation for the EOP's 200-cfs outlet design peak pumping capacity and a 500-cfs bank-full capacity under Scenario B.

OTHER PROPOSALS

67. How do the above degrees of effectiveness compare to other proposals for reducing the level of Devils Lake?

Upper Basin Storage

68. The *Contingency Plan* discussed the State's $5,800,000 plan to retain runoff on public and private lands to prevent or delay an estimated 75,000 ac-ft from reaching Devils Lake, equivalent to nearly 1 foot off the current 1437.7±. This proposal included (1) $2,600,000 for the US Fish and Wildlife Service (USFWS) to develop 14,900 ac-ft of storage on public lands (to supplement 1,300 ac-ft of storage completed in the fall of 1995), (2) a $50,000 NDSWC grant to the Devils Lake Basin Joint Water Resource Board to acquire the rights to 3,000 ac-ft of retention on Conservation Reserve Program (CRP) lands, (3) $800,000 to raise outlet sills in the Chain of Lakes to add 38,000 ac-ft to the lakes' capacity, and (4) $2,450,000 to store 18,000 ac-ft on small private tracts (farmland, potholes, etc.), including an estimated $1,000,000 to construct control structures and an estimated $1,450,000 annually to lease the land for water storage. The North Dakota Congressional Delegation is supporting the State's efforts via Federal funding and coordination.

69. Effects/Issues: (1) Basin water management is recognized as an integral component of an overall solution to water-related problems in the Devils Lake basin and lake itself, particularly when seeking downstream interests' support for an outlet. (2) Upper basin storage would be an intrabasin project, which would not involve interbasin water quality or biota transfer issues. (3) Upper basin storage might "buy time" for more complex solutions to come online and take effect, e.g., an outlet. (4) If implementation of upper basin storage relies on voluntary participation, the amount of storage would vary unpredictably depending on that year's predicted crop prices, whether a parcel is too wet to plant that year, etc. (5) Upper basin storage effectiveness would be reduced should the current wet cycle persist and fill existing and proposed ponding sites. (6) More study is needed to determine how a given volume of upper basin storage affects flow into the lake. (7) There are questions regarding the impacts of upper basin storage on soil salinity and waterfowl botulism.

70. To date, the NDSWC reports that nearly 13,532 ac-ft of upper basin storage is in place or pending, equivalent to about 2 inches off the lake at its current 1437.7±. In addition, the NDSWC (1) is continuing to explore the possibility of additional storage in Sweetwater-Morrison Lake and (2) is promoting development of an interagency database of wetland-related information that might help identify additional opportunities for upper basin storage.

Capturing Big Coulee Inflows

71. The *Contingency Plan* listed two 500-cfs outlet plans that would capture Big Coulee inflows and use the Twin Lakes outlet route or Peterson Coulee outlet route. The *Contingency Plan* cited the NDSWC's concept plans presented to the FEMA Devils Lake Interagency Task Force to raise the Minnewaukan Flats Road to isolate Big Coulee inflows.

a. TWIN LAKES OUTLET -- In contrast to the EOP's three dams/pump stations, the NDSWC's Twin Lakes plan proposed two dams/pump stations and a cut through the top of the divide. The fresher water north of the Minnewaukan Flats Road would be tapped via a 7-mile pipeline and 200-cfs pump station to add to 300 cfs taken from the southern tip of the West Bay. Based on the information in the *Contingency Plan*, the Minnewaukan Flats Road raise, 7-mile pipeline, and new pump station would add an estimated $20,000,000[5] to the cost of the basic Twin Lakes outlet plan. Another possibility would be to lay a pipeline across the bottom of the West Bay in a direct line from north of the Minnewaukan Flats Road to the EOP's intake at Dam/Pump Station #1, which might shorten the pipeline and reduce the added cost.

b. PETERSON COULEE OUTLET -- This route would use a dam/pump station to raise Devils Lake water about 20 feet into a raised and combined Round/Long Lake. From there, a second dam/pump station would lift the water another 85 feet into a raised Stony Lake. At that point, the water would flow via open channel down Peterson Coulee to the Sheyenne River. This proposal would tap up to 500 cfs of the fresher water north of the Minnewaukan Flats Road at a cost estimated at $29,000,000[5] in the *Contingency Plan*.

c. Effects/Issues of discharging coulee inflows via either outlet route: (1) As described in paragraphs 65 and 66, use of Big Coulee inflows before they mix with West Bay water would have reduced water quality constraints on outlet operation and, thus, increased drawdown in the 10-year simulation from 1.09 feet to between 1.56 and 2.13 feet. (2) The cost of the project would significantly increase, and Peterson Coulee might emerge as the preferable outlet route. (3) The capture and discharge of coulee inflow might cause a long-term rise of lake TDS; that potential effect will be explored in the Feasibility Study. (4) The current lake level is already causing backwater effects in Big Coulee that may affect Highway 281 and the Soo Line Railroad's east-west rail line north of Pelican Lake. Any rise in lake elevation from using the Minnewaukan Flats Road as a dam to capture Big Coulee inflows may involve major mitigation costs to protect or raise the highway and rail line. (5) Spirit Lake Nation representatives have indicated that the Nation does not favor plans that would isolate a portion of the lake, as would be the case if a raised Minnewaukan Flats Road was used as a dam. Other options could be explored to tap coulee inflow without damming part of the lake, e.g., a pipeline laid directly into the mouth of the coulee or a pipeline tapping the coulee farther upstream (e.g., near its confluence with Little Coulee).

Treatment of the Lake Water

72. Outlet water quality could be improved by treating the lake water to reduce the TDS and, therefore, sulfate. Three treatment systems were considered -- reverse osmosis, distillation, and freeze-thaw-evaporation. Treatment options may be assessed during the Feasibility Study.

a. REVERSE OSMOSIS (RO) -- Prior to the RO process, the water undergoes a series of pretreatments to remove suspended solids. Then, high pressure forces the water through semi-permeable membranes, leaving the salts behind.

b. The Colorado River desalting plant near Yuma, Arizona, cost over $211,000,000 (1987 dollars) to build and produces about 80,000 ac-ft of desalted water per year (112 cfs for 365 days) for an operating cost of $26,000,000. A similar plant at Devils Lake operating 7 months per year could provide nearly 48,000 ac-ft of desalted water which could then be blended with

[5] This cost estimate was not reassessed during the EOP effort and, therefore, may not be directly comparable to EOP estimates developed with a different level of detail, contingencies, etc.

additional untreated water to produce an outlet sulfate concentration that, combined with the ambient river sulfate, would stay within the 450 mg/l sulfate standard.

c. Effects/Issues: (1) The treated water would still need to be conveyed over the divide to the Sheyenne River. (2) The outlet would be able to stay within the water quality standard, permitting operation restrained only by pumping capacity and bank-full capacity. (3) Sludge and brine disposal. The Yuma plant uses acre-sized evaporation ponds which are buried when the sludge dries; brine at about 10,000 mg/l is discharged into the Gulf of California. How would a Devils Lake plant handle disposal?

d. DISTILLATION -- A full distillation plant would not be needed to meet the objective of removing water from Devils Lake; evaporation of the water would be adequate, with the water vapor carried away downwind. Distillation of the vapor back into water would not be a necessary step (unless the fresh water produced was in great demand by downstream interests); therefore, an outlet would not be needed. A cost estimate was not made for this concept; however, the minimum power requirements of a thermal-based distillation plant can be several times that for a brackish water RO plant, regardless of whether the process adopted was Multiple Effect Distillation (MED) or Multi-Stage Flash (MSF) desalination; an evaporation plant would require a major power source to furnish the heat needed to evaporate up to 200 cfs (400 ac-ft per day). Both construction and operating costs would be very high.

e. Effects/Issues: (1) The outlet would be able to stay within the water quality standard, permitting operation restrained only by pumping capacity and bank-full capacity. (2) Scale removal, disposal of wash water, etc. raise questions similar to those for RO plant sludge and brine.

f. FREEZE-THAW-EVAPORATION (FTE) -- The Energy and Environmental Research Center (EERC) at the University of North Dakota (Grand Forks) is promoting the FTE process. As contaminated water is frozen, salts tend to stay in solution in the unfrozen waste brine, leaving nearly pure ice. A 100,000-gallons-per-day (0.155-cfs) pilot plant was tested over the 1995-96 winter on water contaminated with oil and oil drilling waste in New Mexico. The EERC has applied to the Environmental Protection Agency (EPA) for a $1,900,000 grant to construct a 1,000,000-gallons-per-day (1.55-cfs), 50-acre demonstration project in the Devils Lake basin. In a *Devils Lake, N.D., Journal* article, the EERC estimated that a 100,000,000-gallons-per-day (155-cfs) FTE plant would cost $20,000,000 to build and require 640 acres; an operating cost was not provided.

g. Effects/Issues: (1) The outlet would be able to stay within the water quality standard, permitting operation restrained only by pumping capacity and bank-full capacity. (2) A Devils Lake FTE plant would operate during the winter months, e.g., November - March, 5 months, during which it would have to produce ice equivalent to 7-months of outlet operation up to 200 cfs, i.e., as much as 85,000 ac-ft of treated water. (3) It is premature to speculate about the practicability and efficacy of an FTE plant handling over 200 cfs of Devils Lake water in the climatic regime characteristic of North Dakota winters. Other questions to be addressed include disposal of the brine.

WATER QUALITY EFFECTS

73. Water quality effects from emergency outlet operation were analyzed by using output from the effectiveness simulation for the 10-year period October 1985 through September 1995 (see EFFECTIVENESS section) as input to a model tracking the mass balance of river and tributary inflows and sulfate loads for the Sheyenne River at Warwick, Cooperstown, Baldhill Dam/Valley City, Lisbon,

Kindred, and West Fargo, and the Red River of the North at Halstad, Grand Forks, and Emerson.

74. Figure 20 shows with- and without-project sulfate concentrations on the Sheyenne River at Warwick, below Baldhill Dam (Lake Ashtabula), and at West Fargo:

a. During periods when outlet operation is constrained by the river's 450-mg/l standard, the concentration at Warwick falls below 450 mg/l because of local tributary inflow between the outlet confluence and Warwick. Therefore, Figure 20's flat-topped zones of 400+ mg/l at Warwick reflect extended periods of operation restricted by the river's 450 mg/l sulfate standard. The with-project sulfate abruptly jumps and falls at the start and end of the 1 May - 30 November "windows" of operation. With-project sulfate below 400 mg/l represents periods when bank-full capacity (rather than water quality) was the constraining factor. The magnitude of sulfate change at Warwick was 200 to 300 mg/l on top of typical baseline (natural) values of 100-200 mg/l, i.e., increases of 100 to 300 percent at this station.

b. With-project concentrations below Baldhill Dam are attenuated significantly by mixing with Lake Ashtabula and tributary flows from the outlet to this station. With-project sulfate added a maximum of 50 to 100 mg/l on top of baseline figures closer to 150 mg/l, i.e., maximum increases on the order of 50 percent. The effects from outlet operation in 1987 persisted for years after operation ceased because storage in Lake Ashtabula was large compared to runoff during the drought years 1987-1991. In contrast, Lake Ashtabula freshened rapidly after the 1994 outlet operation because high inflows quickly flushed the lake out.

c. Changes in sulfate concentrations in the lower Sheyenne River during outlet operation are largely a function of the effects of storage in Lake Ashtabula. This effect is reflected in Figure 20, which shows that the added sulfate at West Fargo is basically the same as that at Baldhill Dam.

75. Figure 21 shows the attenuating effects of the higher flows in the Red River at Halstad, Grand Forks, and Emerson. Impacts on Red River sulfate from operations in 1987 and 1994 are minor; 1995 operation increased sulfate somewhat more, a maximum of about 20 mg/l on top of a baseline of about 100 mg/l, i.e., 20 percent.

76. The 450 mg/l sulfate standard for the Sheyenne River and 250 mg/l sulfate standard for the Red River and objective at the International Border were not exceeded during the simulated operation. It is necessary, however, to determine if communities using the river for water supply might incur higher treatment costs due to increases in sulfate and other water quality parameters during outlet operation; as shown by this simulation, such effects can persist long after operation ceases.

77. This 10-year simulation is helpful in illustrating several facets of real-time outlet operation:

a. Operational decisions are vulnerable to time- and distance-related fluctuations from conditions extant at the decision point. Example 1: Operators in 1987 could not have foreseen the impending 5-year drought that would (a) draw Devil Lake down to a point of concern for the fishery and (b) cause effects of the 7-month pumping operation to persist at Lake Ashtabula and points downstream for years. Example 2: Rainfall runoff events concurrent with operation might result in downstream flooding that would not have occurred in the absence of outlet flow.

b. The simulation suggests that meeting the Sheyenne River's 450 mg/l sulfate standard protects against exceedences of the 250 mg/l standard on the

Red River and objective at the International Border. Because sulfate is a component of TDS, we might expect TDS increases proportional to the simulation's sulfate increases. Therefore, because (1) travel time from the outlet to the Red River can exceed 2 weeks, (2) outlet operators cannot forecast downstream conditions weeks ahead of time, and (3) baseline TDS on the Red River can exceed the Red River's TDS standard and border objective of 500 mg/l, outlet operations could increase the frequency, duration, and magnitude of those instances.

78. The WATER QUALITY EFFECTS APPENDIX shows the water quality impacts at all nine sites for three of the outlet operation scenarios examined during the effectiveness sensitivity tests -- the EOP's 200-cfs outlet design peak pumping capacity and 500-cfs bank-full capacity, a 300-cfs design peak capacity and 500-cfs bank-full capacity, and a 557-cfs maximum outlet discharge and 600-cfs bank-full capacity.

ENVIRONMENTAL RESOURCES EFFECTS AND MITIGATION

ENVIRONMENTAL EFFECTS

79. Along the outlet route, an estimated 770 acres of wetlands, 150 acres of grassland, and 50 acres of woodland would be affected, either by construction, inundation, or water quality changes during outlet operation. Figure 22 shows wetlands identified by the National Wetland Inventory along and adjacent to the outlet route. The figure shows areas that would be affected by construction or water quality changes during operation.

80. The effects in Devils Lake and the receiving waters associated with operation of the outlet have not been quantified. Although operation of the outlet would be constrained by the Sheyenne River's bank-full capacity and sulfate standard,[6] flow and TDS levels would increase in the Sheyenne River and Red River of the North. Potential effects include changes in flow conditions, water quality, and groundwater elevations that, in turn, may result in subtle long-term changes to existing ecosystems and may not be readily noticeable or quantifiable without extensive monitoring programs.

81. Biota transfer from Devils Lake to the Red River drainage basin has been identified as a concern in past studies. A recent evaluation of emergency outlet operation with respect to biota transfer identified no impacts, potential threats, or areas of concern for the following existing biota -- fish, macrophytes, algae, pathogens, and invertebrates. The evaluation identified a slight potential for increased phosphorus loading, which could affect the algal community in Lake Winnipeg. The evaluation also indicated that, while it was unlikely, it was not impossible that unique pathogens for pike, walleye, and perch could be introduced to the receiving water through fish escaping from Devils Lake via the outlet.

82. Bioaccumulation of mercury is a potential problem in Devils Lake, the Sheyenne River, and the Red River. There have been mercury advisories in all three areas in the past. The mercury advisory in Devils Lake was probably due to inundation of organic material that had not been flooded for many years, and subsequent methylation of mercury. Operation of an outlet could increase the potential for higher mercury levels in downstream aquatic systems; however, the likelihood of a measurable increase in mercury levels is con-

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[6] The North Dakota standard for sulfate concentration in the Sheyenne River is 450 mg/l. There is no TDS standard for the Sheyenne River. North Dakota and Minnesota standards for TDS and sulfate for the Red River of the North are 500 mg/l and 250 mg/l, respectively. Objectives at the International Border match the Red River standards.

sidered slight. This is a potential effect that would require more detailed evaluation.

83. Archeological and architectural sites located along the proposed outlet route could be affected by its construction or operation. Because most of the outlet route has not been surveyed for cultural resources, it is not known how many sites are located along the outlet alignment. As of June 15, 1996, there are no sites along the outlet route known to be listed on or eligible for the National Register of Historic Places. Traditional cultural properties along this route have yet to be inventoried, so potential effects to this type of cultural property are unknown at this time.

84. Archeological sites along the Sheyenne River may be affected by increased erosion that could occur with operation of an outlet.

85. For more details about the existing environmental conditons and potential environmental effects, see the ENVIRONMENTAL RESOURCES APPENDIX.

MITIGATION

86. Construction and operation of an emergency outlet from Devils Lake would require development and implementation of a mitigation plan to compensate for unavoidable losses. The table below shows suggested mitigation actions at this time. Compensation for effects on wetlands, woodlands, and grasslands along the outlet alignment could be provided through a combination of management of project lands and acquisition and management of separable lands. The preliminary estimate of mitigation costs for impacts along the outlet alignment is presented in the COST ESTIMATE section and ENVIRONMENTAL RESOURCES APPENDIX. Mitigation needs for Devils Lake itself and downstream receiving waters would be identified by the proposed long-term monitoring.

EVALUATION AREA	HABITAT AREA LOST OR AFFECTED	MITIGATION ACTION
Twin Lakes outlet route	970 acres	Acquisition and management
Devils Lake	Has not been determined at this time	Monitoring
Sheyenne River / Red River of the North	Has not been determined at this time	Monitoring

87. Due to the preliminary nature of the EOP and uncertainties regarding effects from operation of the outlet, more detailed information is required to fully identify the impacts of an emergency outlet. Ideally, mitigation features should be implemented concurrently with construction. However, should it be directed that the project be constructed prior to the completion of needed studies, detailed monitoring programs will be developed in order to quantify the effects of construction and operation, and appropriate mitigation features designed and implemented in a timely manner. Extensive and long-term monitoring would be required to fully identify effects in Devils Lake and downstream that could occur with operation of an outlet. Studies would be required in the areas of water quality, groundwater, aquatic resources, lake levels, terrestrial habitat, social acceptability, coultural resources, downstream water quality, recreation, etc. The types and scopes of needed studies would be developed in coordination with other Federal, State, and local agencies. The extent and cost of these programs have not been identified at this time.

88. Some measures may be required to ensure that the hatchery operations on the Sheyenne River are not adversely affected. Such measures may include water treatment facilities or providing alternate water sources. Costs for these measures are not estimated at this time.

89. If any cultural resources sites or traditional cultural properties found along the emergency outlet route are evaluated as being eligible for listing on the National Register of Historic Places and cannot be avoided, potential impacts to those sites or properties would have to be mitigated. Mitigation measures may include a combination of formal excavation, archival research, oral histories, Historic American Building Survey/Historic American Engineering Record (HABS/HAER) recordation, and/or replacement planting of traditionally used plants.

90. Coordination has been initiated with the Spirit Lake Nation regarding the presence of traditional cultural properties along the proposed Twin Lakes emergency outlet route, the Devils Lake shoreline, and the Sheyenne River. Because of their historical associations with the Devils Lake region, the Hidatsa will also be consulted regarding traditional cultural properties in the project vicinity. The Hidatsa are currently part of the Three Affiliated Tribes and, along with the Mandan and Arikara, are located on the Fort Berthold Reservation on the Missouri River in the New Town vicinity.

91. For more detail regarding mitigation, see the ENVIRONMENTAL RESOURCES APPENDIX.

ISSUES OF CONCERN

92. Construction of the emergency outlet may be viewed as the first step in implementing features for stabilization of Devils Lake. Proceeding with construction of an outlet on an emergency basis will most likely generate considerable public and agency controversy in both the United States and Canada. Implementation of this feature would require preparation of an EIS.

93. During the preparation of the *Contingency Plan*, downstream concerns were identified via letters, faxes, and verbal statements at public meetings held in Lisbon and Valley City, ND, on 31 January 1996. Downstream concerns include the following:

a. Environmental
- An altered flow regime (in particular, long-term bank-full flow) might adversely affect the aquatic community
- ... increase groundwater levels adjacent to the river, thereby changing floodplain vegetation
- ... alter adjacent land use.
- Will the added salinity and possibility of mercury and other heavy metals affect the river's fishery?
- Will the added drainage area increase phosphate runoff, hence, algal blooms?

b. Flooding
- A bank-full river during outlet operation poses a threat of downstream flooding from coincidental thunderstorm events. Throttling back the outlet when a major runoff event is anticipated would not help because an outlet release can take 2 or more weeks travel time to reach the RRN.[7]

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[7] During the Feasibility Study, analyses will be made regarding the possibility of a "buffer" of X cfs below the river's bank-full capacity to handle possible runoff events.

- Would higher river flows from outlet operation affect the regulatory floodplain (hence, change Flood Insurance Rate Maps)?
- Would higher winter or spring flows increase the frequency or severity of ice jams and cause more flooding?
- Who would pay for induced damages from higher water downstream?
- ... if Valley City has to raise its dikes?
- ... for relocations of structures flooded more frequently due to higher river stages?
- Should the Lisbon emergency dike system be upgraded because of the higher river flows?

c. Erosion
- Would higher river flows increase riverbank erosion?
- Downstream residents contend that, before the Baldhill Dam was built, spring flood flows passed before the riverbanks thawed; therefore, erosion was minimal. Today, water stored by Baldhill operation to lower the peak stage has to be released over a longer duration of high flows, which increases erosion. Would added flow from a Devils Lake outlet worsen the situation?
- Increased erosion could result in loss of Woodland Period Native American cultural resource sites and of riverbank trees.

d. Farming
- Farmers adjacent to the Sheyenne River are concerned that outlet operation will increase river flow and, in turn, raise the water table and affect farming operations. Some farmers contend that operation of the Baldhill Dam already keeps the river high too long and prevents normal drainage of farmland; they feel that outlet operation would exacerbate those problems. Farmers in the Sheyenne delta area miles from the river assert that, because of the porous soils, they already are experiencing problems with a higher than normal water table from prolonged high river stages. Would added flow from a Devils Lake outlet worsen the situation?
- Farmers owning land on both sides of the river rely on low-flow crossings to get stock and equipment across. Would outlet operation increase river levels and interfere with or prevent crossing?
- Would water quality impacts from outlet operation affect the river's suitability for stock watering?

e. Roads and bridges
- Would downstream roads and bridges suffer damages from higher river flows?

f. Community water supply
- Will water quality changes (TDS, heavy metals, etc.) affect the Valley City water supply?

g. Other
- Wintertime operation of the outlet could weaken the river's ice cover and pose a threat to snowmobilers and other recreational users of the river corridor. Weakened ice also could prevent use of the ice cover for clearing and snagging operations.
- Will water quality effects have adverse impacts on Lake Ashtabula recreation?

94. Numerous studies have been completed in the Devils Lake basin. Significant resources and concerns that were identified during those studies would need to be addressed should construction of the emergency outlet proceed. A preliminary list of potential significant environmental resources that have been identified on the basis of public interest, law, and/or technical criteria is presented in the ENVIRONMENTAL RESOURCES APPENDIX.

SOCIAL IMPACT ASSESSMENT

95. A social impact assessment will be required as part of the EIS, whether an EIS is done in conjunction with the Devils Lake Feasibility Study or independently for the emergency outlet alone. Past studies have indicated that the proposed emergency outlet is the type of alternative that will affect a number of social and economic parameters, including recreation, public health and safety, community growth and development, and community cohesion and controversy. The proposed outlet would also have some effect on flood damage reduction, transportation, aesthetics, and land use. Social impacts will be directly related to project design and performance, as well as resultant environmental effects, such as fishery and water quality impacts.

96. Effects will be distinguished for at least three geographically distinct populations -- persons living in immediate proximity to Devils Lake, persons living along the outlet route, and persons living downstream of the outlet's confluence with the Sheyenne River. Concerns and effects will be different among these groups, and they will be analyzed accordingly. Techniques used to gather information on effects could include mail and telephone surveys, institutional analyses, focus groups, public meetings, and other forms of public involvement. Issues will range in scope from the individual's level (e.g., stress and uncertainty related to flooding), to upstream/downstream concerns between groups, to the international level (water quality and biota transfer issues involving Canada).

COST ESTIMATE

97. The following table shows estimated first costs and annual operation, maintenance, and replacement (OM&R) costs for the diesel-powered, 200-cfs capacity, emergency outlet plan. First costs include planning, engineering, and design (PED); construction; construction management (supervision and inspection during construction); real estate; environmental mitigation; and contingencies. OM&R costs cover fuel; repair/maintenance of the channels, embankments, riprap, access roads, pumps, motors, gates, etc.; and major replacement items (e.g., pumps, motors).[8]

98. Assumptions and contingency factors used in the cost estimate are commensurate with the preliminary nature of the project's major features. Therefore, the estimate cannot be used as a project baseline cost estimate.

99. The COST ESTIMATE APPENDIX provides more detailed discussions of the cost estimating methodology, contingencies, and options (200-cfs/electrical power; 300-cfs/diesel power).

IMPLEMENTATION

100. Prior to implementation, an outlet would have to satisfy normal Federal environmental, economic, and engineering criteria, and be authorized by Congress. In addition, funding would have to be obtained through a separate budget process.

---

[8] PED and construction management were taken as percentages of construction cost (see COST ESTIMATE APPENDIX). Operating cost estimates were based on fuel consumption. Maintenance and replacement costs were estimated at 1 percent of the construction cost with contingencies. The environmental mitigation cost estimate covers just quantifiable elements; the identification of additional mitigation for downstream impacts is dependent on the proposed monitoring program discussed further in the ENVIRONMENTAL RESOURCES EFFECTS APPENDIX.

ITEM	ESTIMATE[1]
First Costs:	
Dams	$ 4,075,000
Channels	5,254,000
Pump stations	6,006,000
Environmental mitigation	1,576,000
Real estate	293,000
PED	3,162,000
Construction management	1,097,000
Total First Cost	$21,463,000
Annual OM&R:	
Operating (7-month scenario)[2]	$660,000
Operating (per 100,000 ac-ft)[3]	$1,060,000
Downtime[4]	$210,000

1 Includes contingencies.
2 Assumes operation 7 months per year, 2⅓ months each at full, three-quarter, and half capacity. OM&R cost estimates are developed in the MECHANICAL, ELECTRICAL, AND ARCHITECTURAL ENGINEERING APPENDIX.
3 OM&R to pump out 100,000 ac-ft.
4 M&R assuming full-year downtime (e.g., if Devils Lake lowers to a safe elevation).

101. An outlet project would have to fulfill NEPA requirements, in particular, preparation of an EIS. EIS-related activities and likely timelines include the following:

a. File a Notice of Intent to prepare an EIS, which, because of the complexity of the Devils Lake problem and solutions, would trigger a 6±-month public scoping process to identify significant resources and potential effects from Federal, State, and local perspectives.

b. Prepare the draft EIS, an estimated 2-year process including evaluation of alternatives, cultural resources surveys along the outlet route and Sheyenne River, identification of threatened and endangered species, social impact assessment, etc.

c. Hold a 45-day public and agency review period, which likely would be extended to 60 days.

d. Respond to comments on the draft EIS, an estimated 2-month process.

e. Prepare and issue the final EIS, an estimated 1-month process.

f. Conduct a 30-day public and agency review period, likely extended to 45 days.

g. Respond to comments on the final EIS, an estimated 1-month process.

h. Issue the Record of Decision (ROD), which would be done at the time a recommendation is made to the Congress for authorization of a project.

102. The EIS process alone could total 3 years. In addition, some downstream impacts are likely to require long-term monitoring during project operation to identify and to determine necessary mitigation requirements. Therefore, the overall environmental effort may take 4 or more years.

103. Engineering needs include preparation of a design memorandum (or separate memorandums for key features) based on field work, geotechnical sampling, laboratory testing, engineering analyses, and design work to replace assumptions made in this EOP regarding foundation conditions, slope stability, pile and bearing capacity, groundwater effects, hydraulics, hydrology, etc. Other activities include:

a. Qualitatively and quantitatively address downstream concerns (e.g., those issues identified in paragraph 93).

b. Submit project documents for review and approval by HQUSACE, ASA(CW), and the Administration before submittal to Congress for authorization and funding.

c. Prepare contract documents (i.e., plans and specifications).

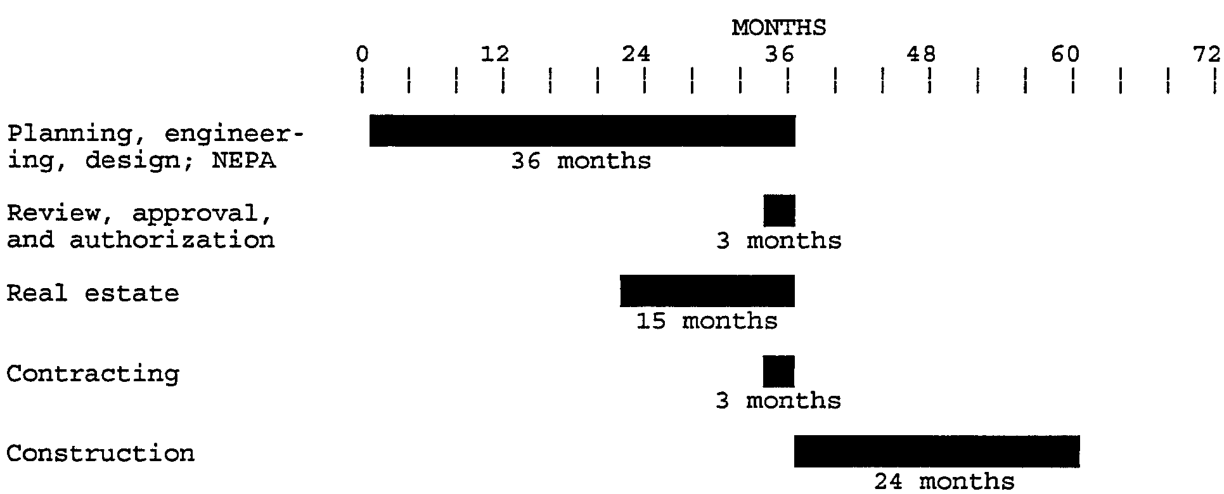
d. Prepare and execute a Project Cooperation Agreement (PCA) between the Government and a suitable non-Federal Sponsor.

e. Acquire the requisite real estate interests along the outlet route.

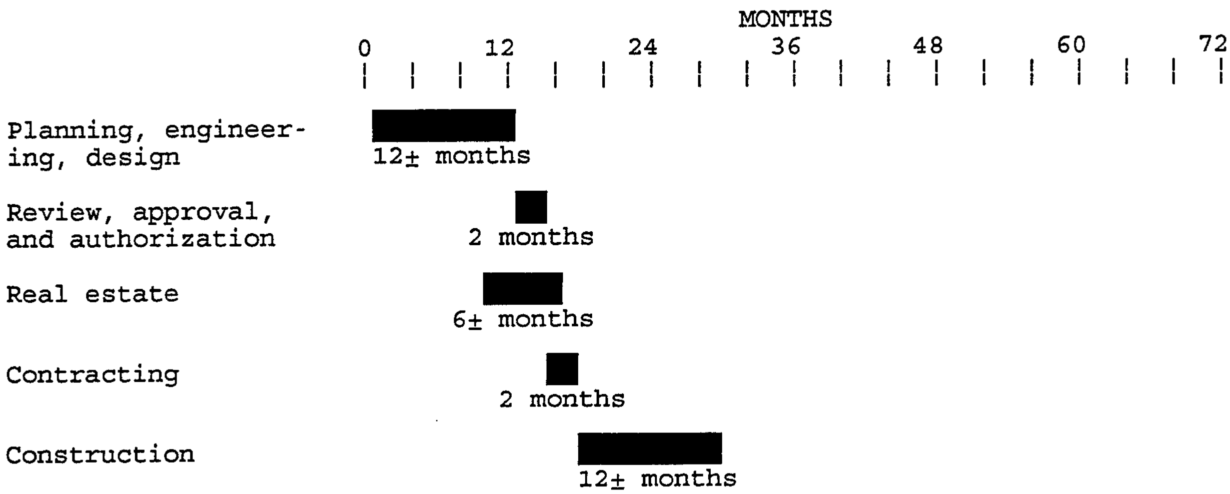
f. Solicit and review contractor bids; award the contract.

g. Construct the outlet (expected to extend over two construction seasons).

104. The schedule shown below is a 60-month time frame for the above activities that presumes activities are done concurrently whenever possible, that waivers are granted for real estate and contracting actions prior to full review and approval, and that no major setbacks are encountered, i.e., downstream issues can be mitigated satisfactorily, no critical engineering problems are identified, Congress and the State of North Dakota provide construction authority and funding for the Federal and non-Federal cost shares in a timely manner, real estate does not run into major obstacles, and litigation is avoided.



105. The above time frame might be shortened with a specific Congressional emergency authorization and funding. The tentative 29-month implementation schedule shown below would require modifying NEPA compliance and waiving other requirements, e.g., having the non-Federal Sponsor acquire minimal up-front real estate interests in advance of authorization, accelerating contracting procedures, and eliminating detailed designs and using a design/build type of contract with extensive field engineering. Construction with this process would likely be more costly than with the 60-month scenario. In addition, this timeline would require extraordinary coordination and cooperation between Devils Lake interests, downstream interests, environmental agencies and special interest groups, State of North Dakota and Minnesota agencies, Federal agencies, and the Canadian and Manitoban Governments. The resulting time frame is shown below.



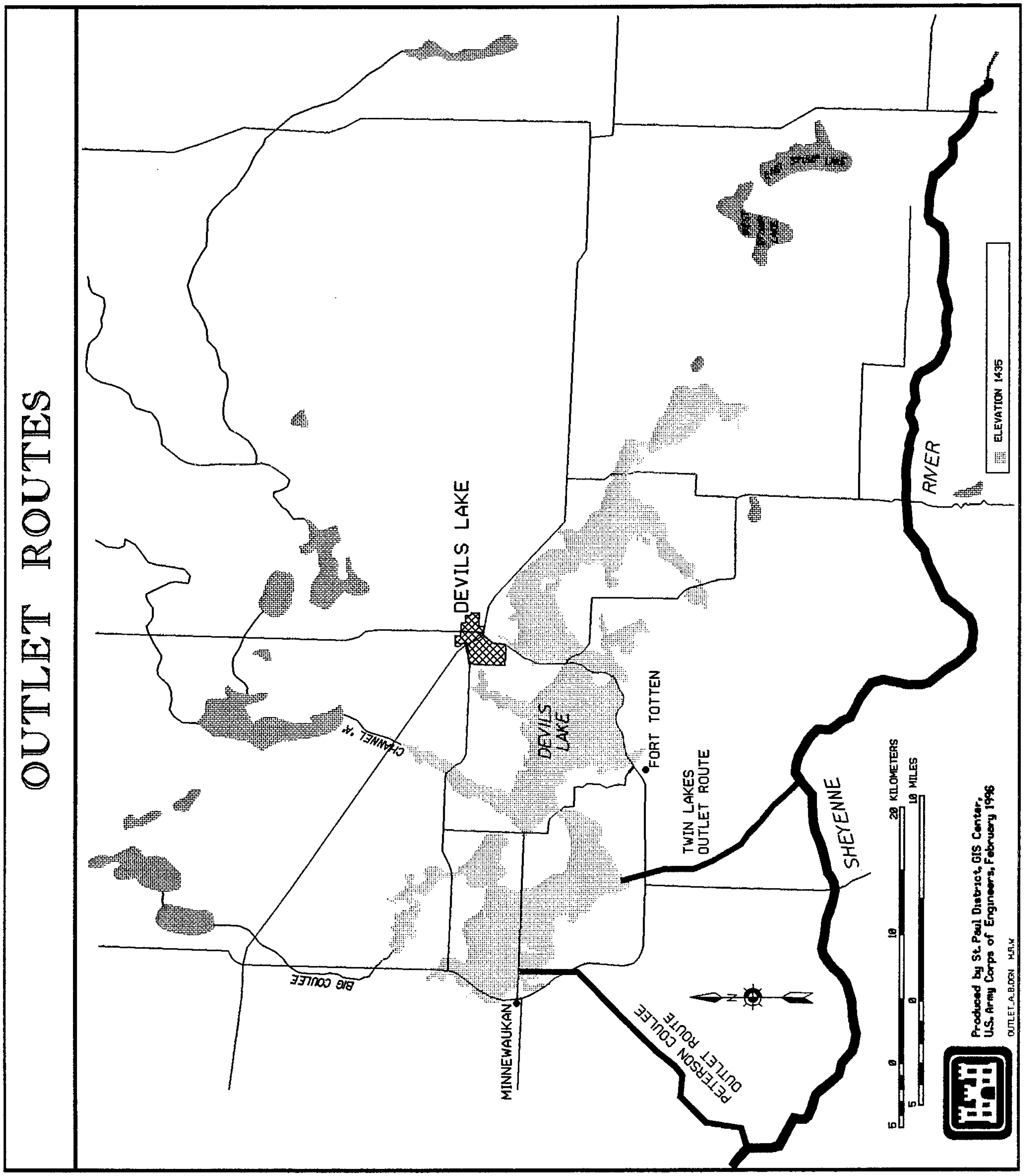
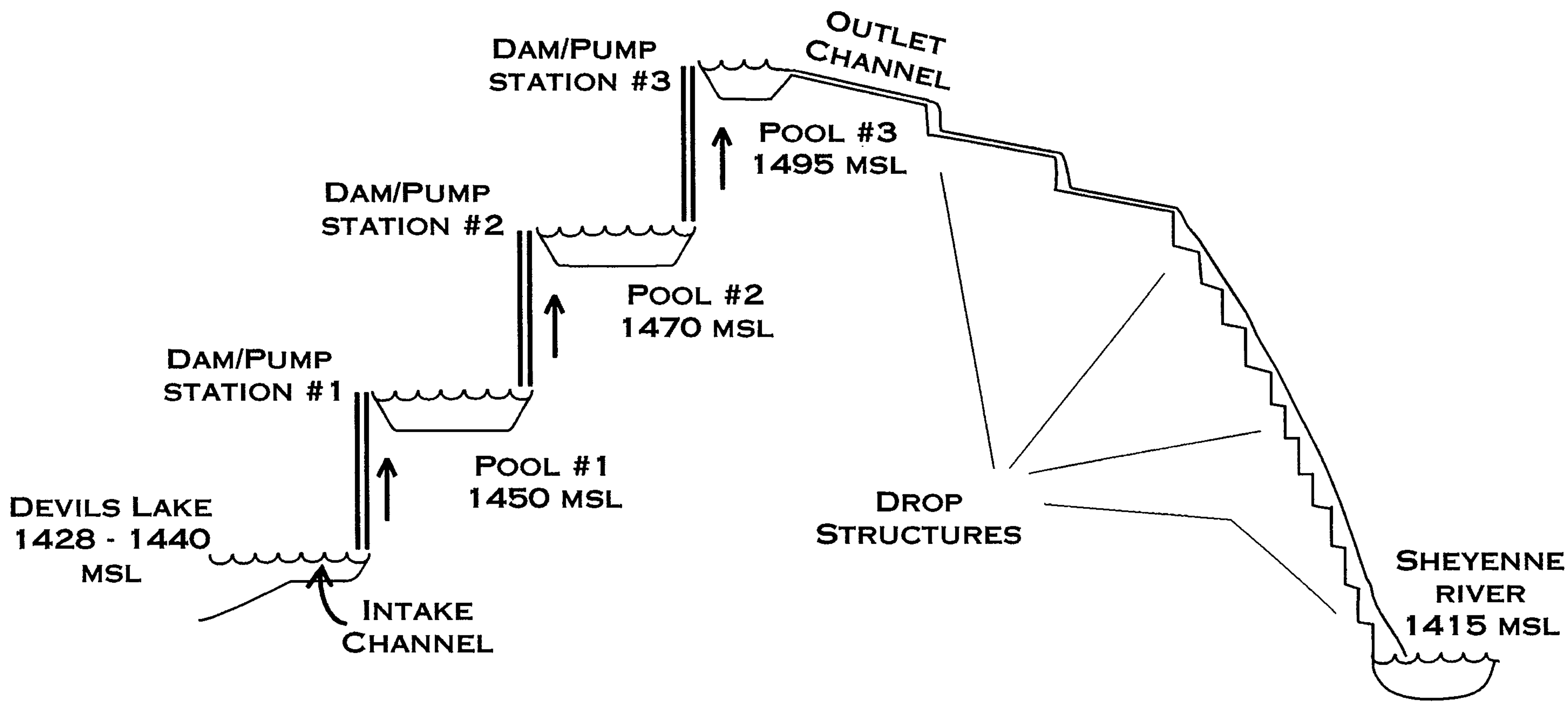

OUTLET ROUTES
DEVILS LAKE
CHANNEL "A"
BIG COULEE
DEVILS LAKE
FORT TOTTEN
MINNEWAUKAN
PETERSON COULEE OUTLET ROUTE
TWIN LAKES OUTLET ROUTE
SHEYENNE
RIVER
ELEVATION 1435
20 KILOMETERS
10 MILES
Produced by St. Paul District, GIS Center, U.S. Army Corps of Engineers, February 1996
OUTLET_A.DGN M.R.W

Figure 1

SCHEMATIC OF TWIN LAKES EMERGENCY OUTLET PLAN

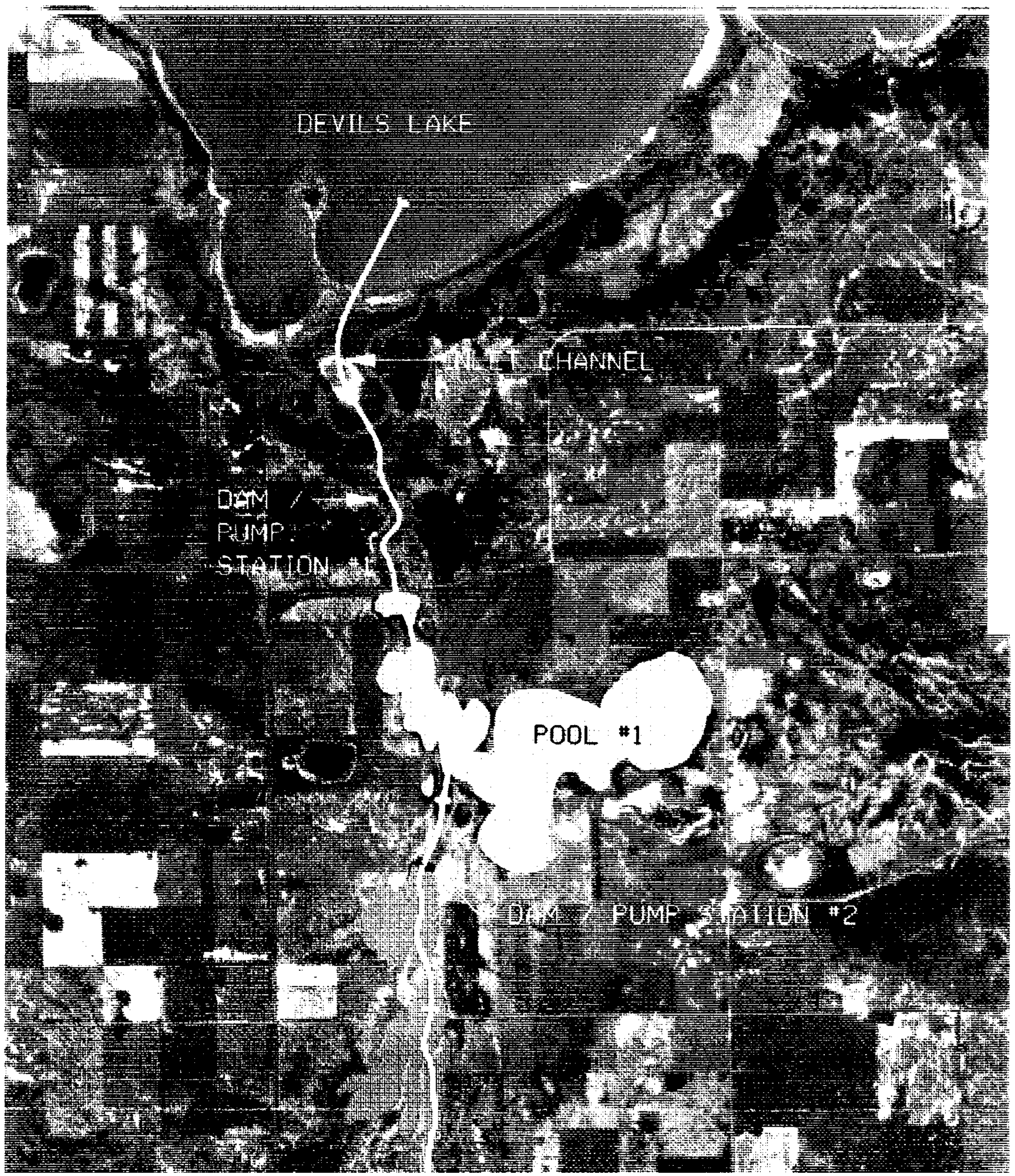


V076TR01

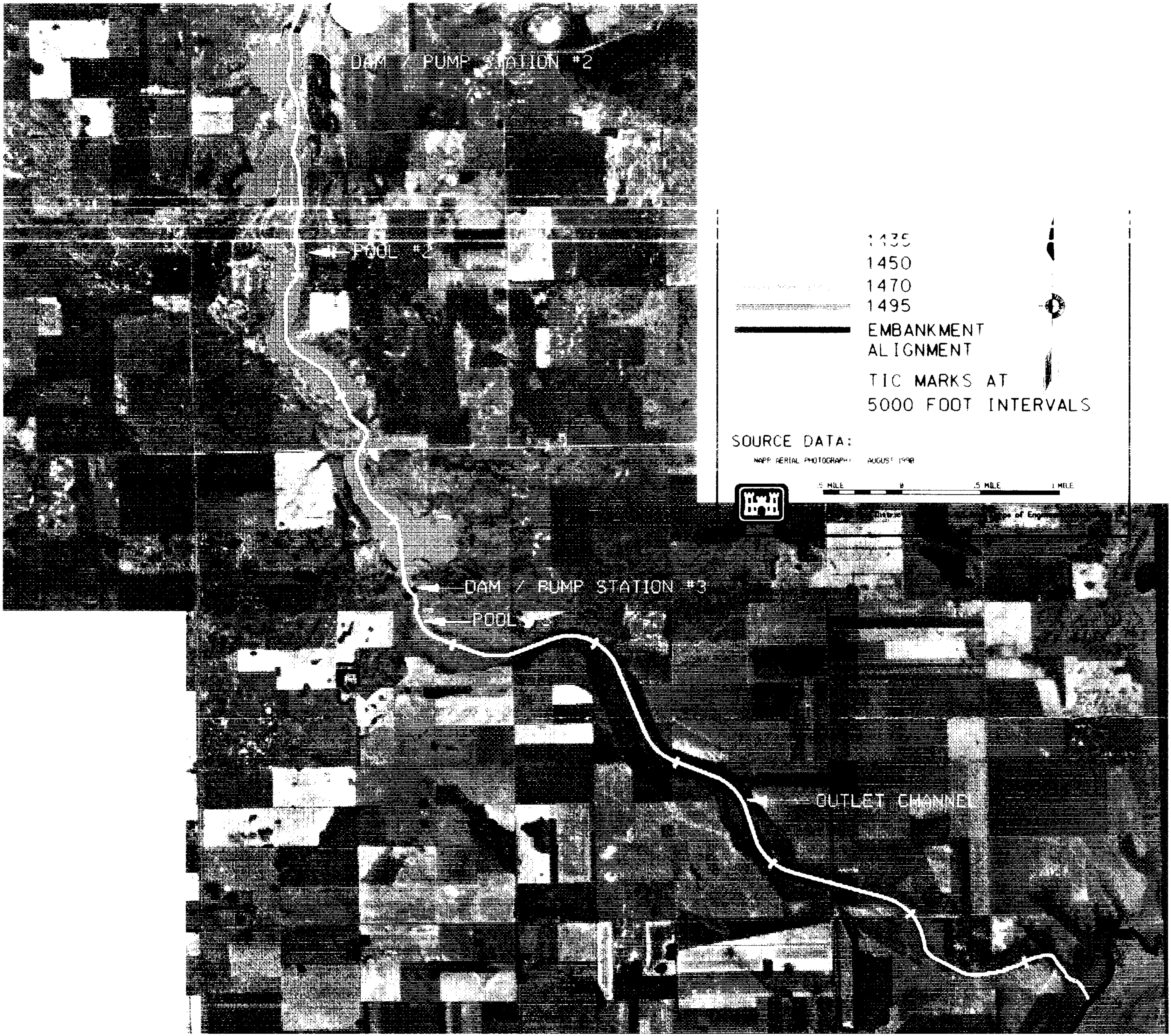
Figure 2

(i)

POOLS AND DAMS/PUMP STATIONS



②



DAM / PUMP STATION #2
POOL #2
DAM / PUMP STATION #3
POOL #3
OUTLET CHANNEL
1435
1450
1470
1495
EMBANKMENT ALIGNMENT
TIC MARKS AT 5000 FOOT INTERVALS
SOURCE DATA:
NAPP AERIAL PHOTOGRAPHY AUGUST 1990
.5 MILE
0
.5 MILE
1 MILE

3

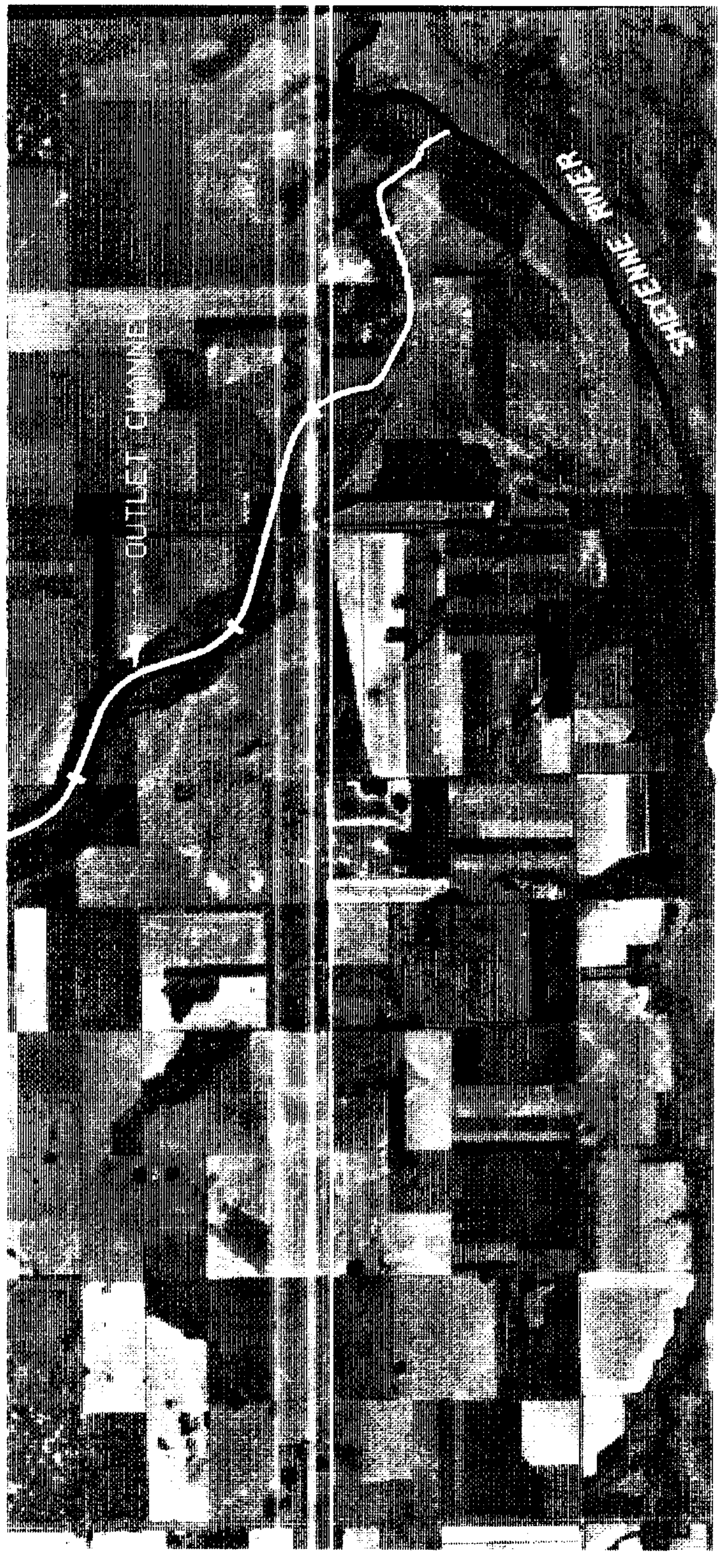
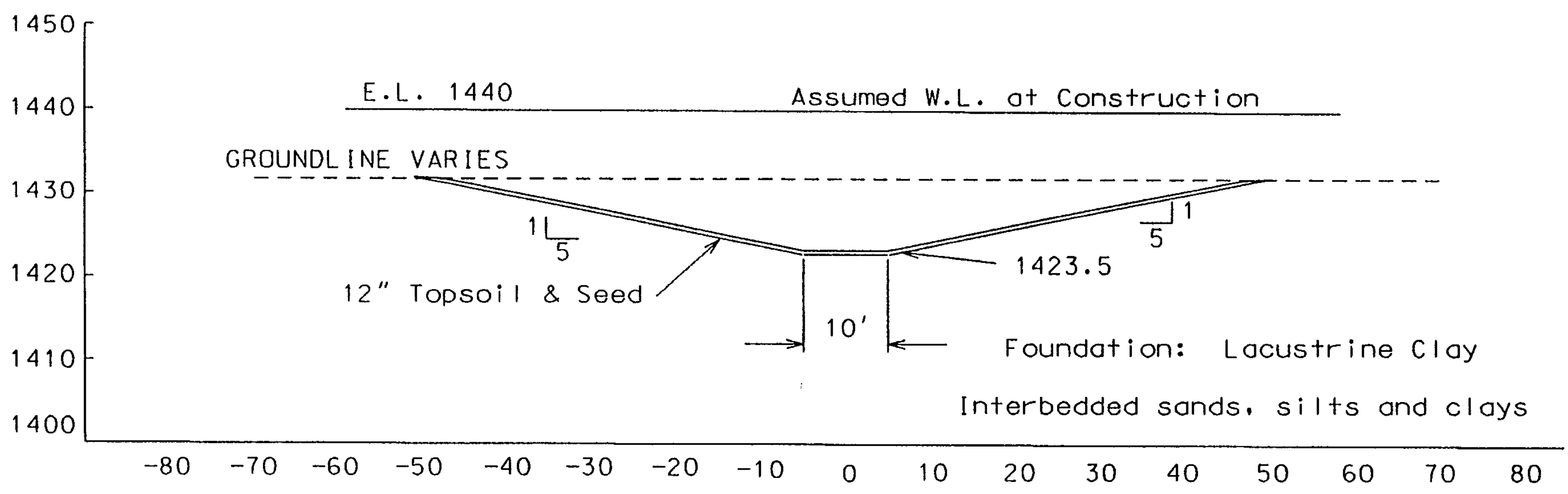


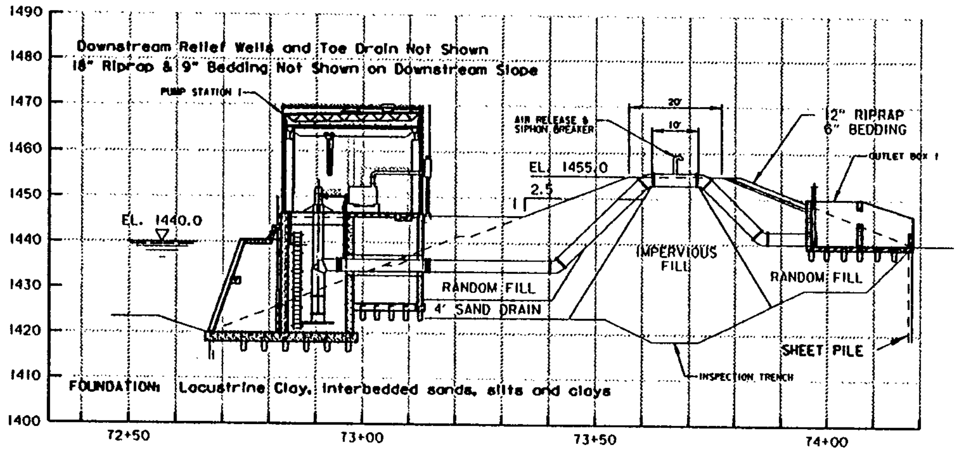
Figure 3



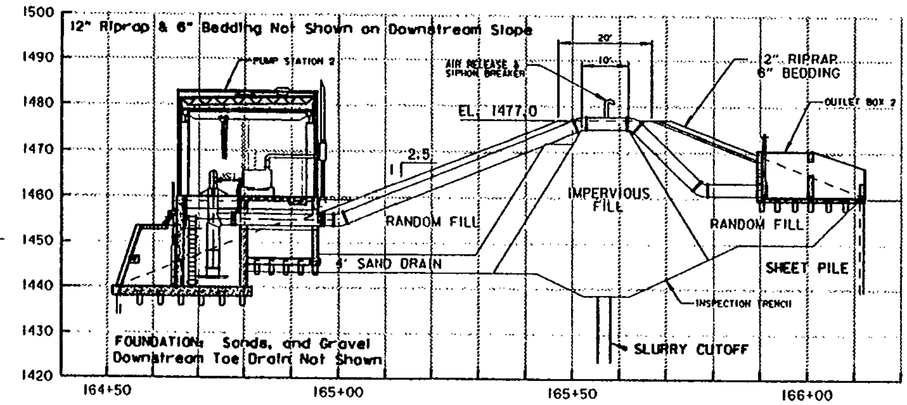
TYPICAL INLET CHANNEL SECTION
STATION 0+00 THRU 73+00

Note: Topsoil & Seed Placed After Lake Level is Drawn Down

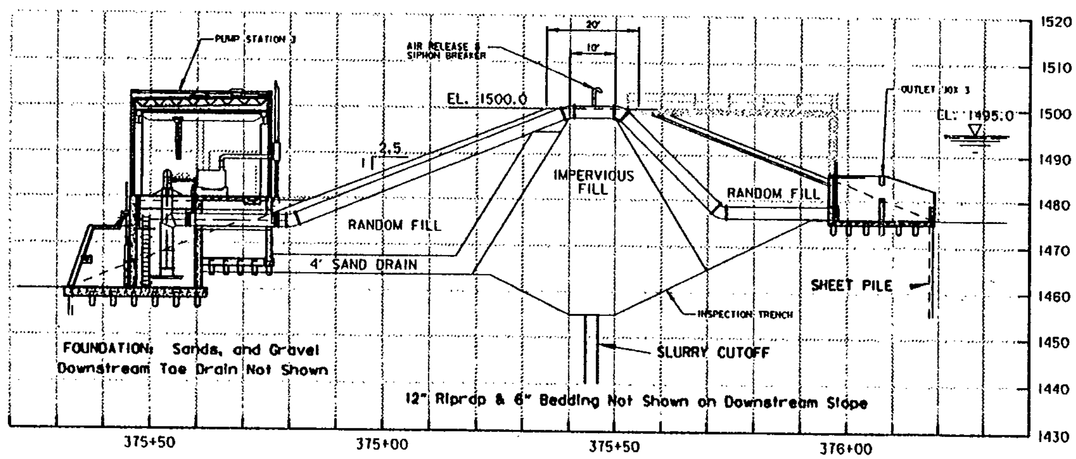
Figure 4



DAM (EMBANKMENT) NUMBER 1



DAM (EMBANKMENT) NUMBER 2



DAM (EMBANKMENT) NUMBER 3

NOTES:

1. TIMBER PILES 40 FEET IN LENGTH ARE ASSUMED
2. THE SAND DRAIN VARIES WITH GROUND SURFACE WITH A 2' MIN. THICKNESS
3. THE TOE DRAIN HAS A 4' TOP WIDTH WITH 8" PERFORATED PVC PIPE DRAINING INTO THE PUMP STATIONS
4. EMERGENCY SPILLWAY FOR DAM #2 IS NOT SHOWN

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

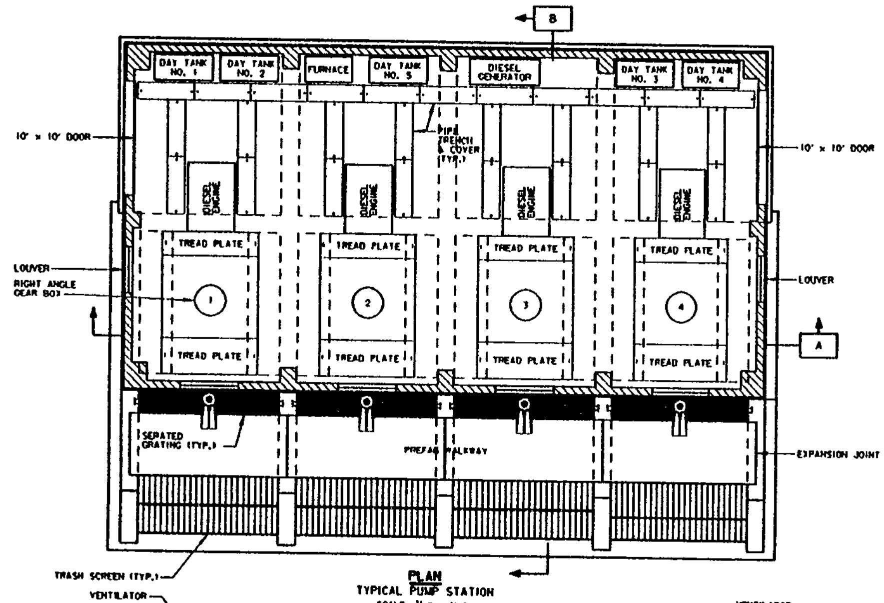
RE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
EMBANKMENT CROSS SECTION
AT CENTERLINE OF CHANNEL

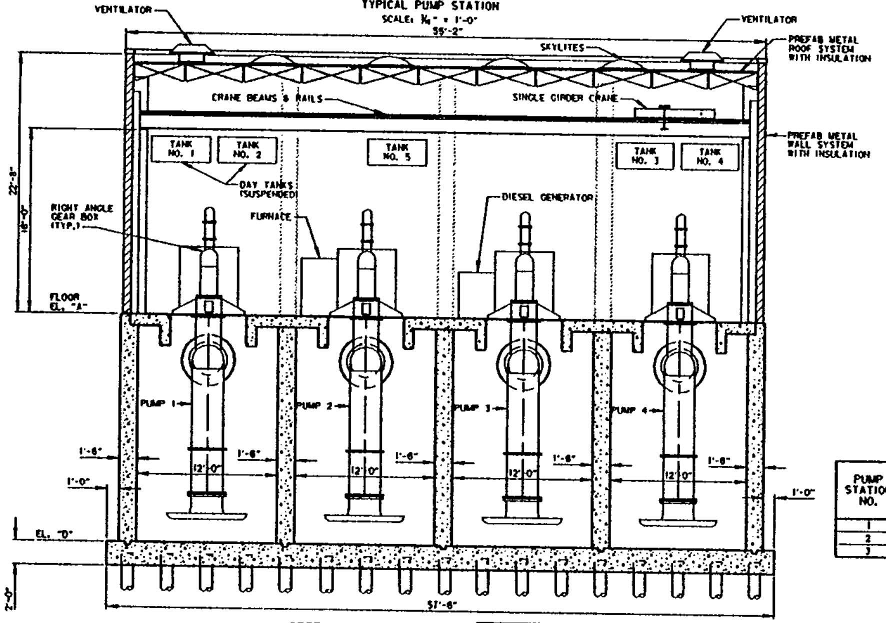
DESIGNED:
CHECKED:
DRAWN: LFT
DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-15-98

CAD FILE NAME: GEOXSEC.DGN
SOL. NO:
DRAWING NUMBER: PLATE 4
SHT 8 OF 11

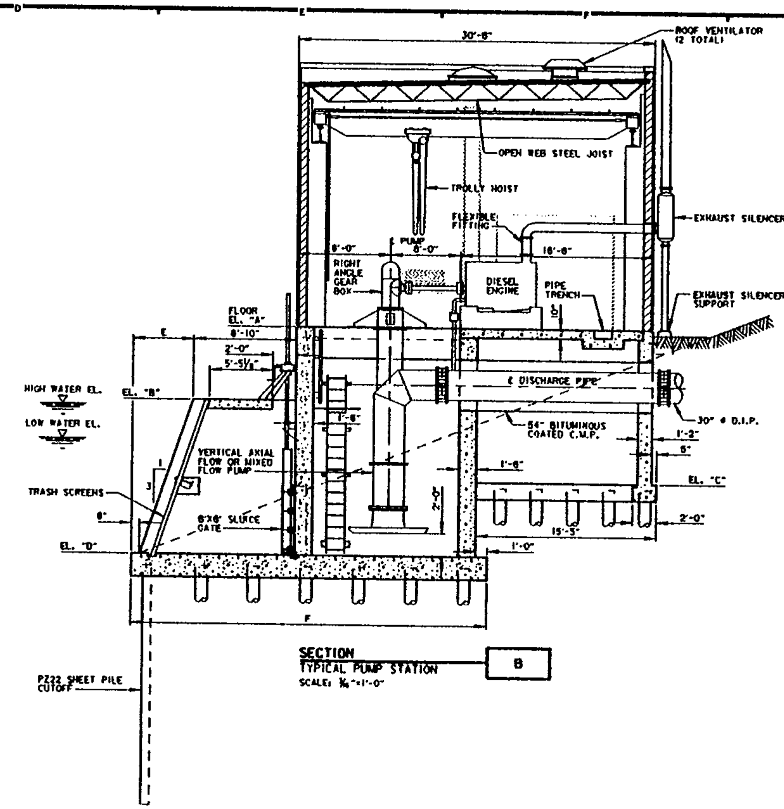
Figure 5



PLAN
TYPICAL PUMP STATION
SCALE: 1/8" = 1'-0"



SECTION A
TYPICAL PUMP STATION
SCALE: 1/8" = 1'-0"



SECTION B
TYPICAL PUMP STATION
SCALE: 1/8" = 1'-0"

NOTES:

1. DAY TANKS 1 THROUGH 4 ARE FOR SUPPLYING FUEL TO DIESEL ENGINES 1 THROUGH 4.
2. DAY TANK 5 IS FOR THE FURNACE.
3. THE DAY TANK FOR THE GENERATOR IS SKID MOUNTED.

PUMP STATION NO.	STATION	ELEVATIONS A	B	C	D	℄ DISCHARGE PIPE	LOW WATER	HIGH WATER	DIMENSIONS E	F
1	13+87	1446.5	1440.5	1428.5	1420.0	1435.0	1428.0	1440.0	7'-4"	32'-8"
2	165+57	1460.0	1453.5	1448.5	1440.0	1455.0	1450.0	1453.0	5'-2"	30'-8"
3	315+45	1480.0	1473.5	1468.5	1460.0	1475.0	1470.0	1473.0	5'-2"	30'-6"

SCALE: 1/8" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

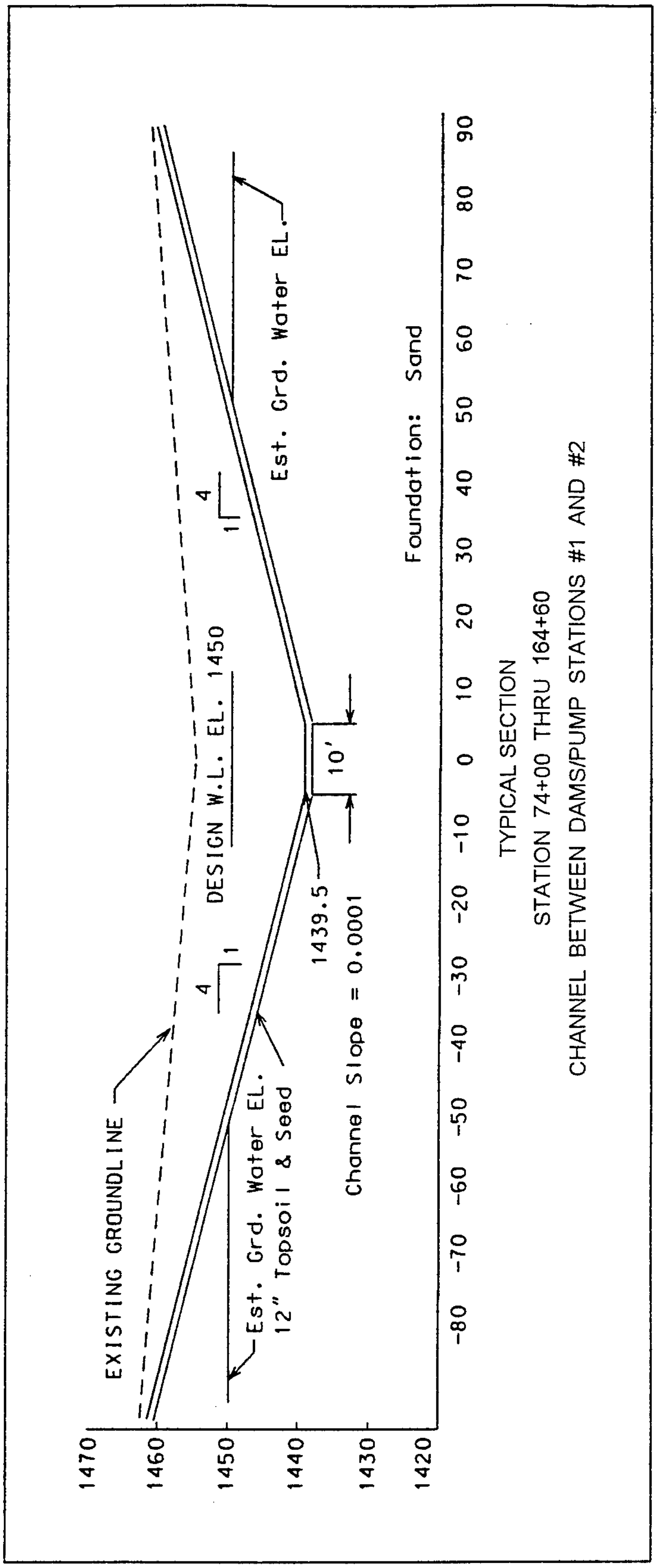
DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
PUMP STATION
PLAN, SECTIONS & TABLE

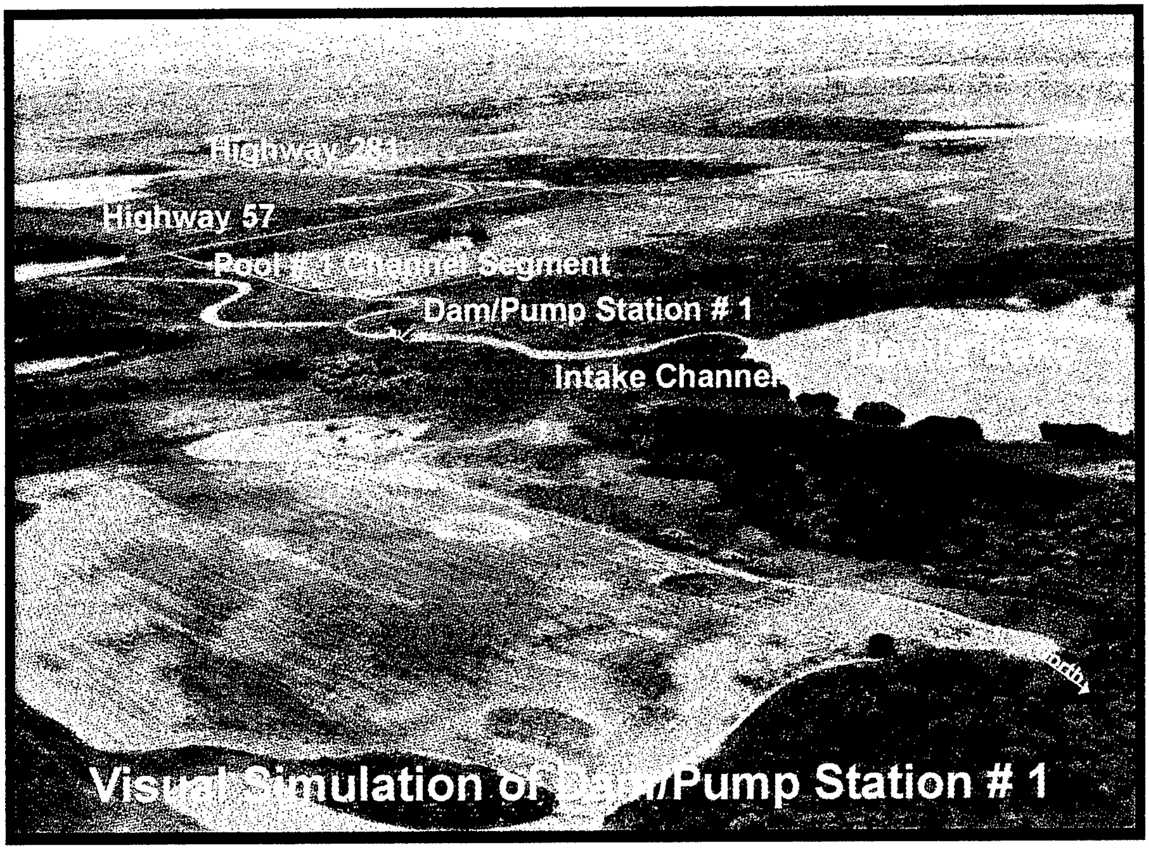
DESIGNED: BGS/TMP
CHECKED: DMT
DRAWN: LKT
DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-12-98
CAD FILE NAME: DVOSRS01.DGN
SOL. NO:
DRAWING NUMBER: PLATE 1
SHT 1 OF 8

Figure 6



EXISTING GROUNDLINE
DESIGN W.L. EL. 1450
4
1
Est. Grd. Water EL.
12" Topsoil & Seed
1439.5
10'
Channel Slope = 0.0001
Foundation: Sand
1470
1460
1450
1440
1430
1420
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90
TYPICAL SECTION
STATION 74+00 THRU 164+60
CHANNEL BETWEEN DAMS/PUMP STATIONS #1 AND #2

Figure 7



Visual Simulation of Dam/Pump Station # 1

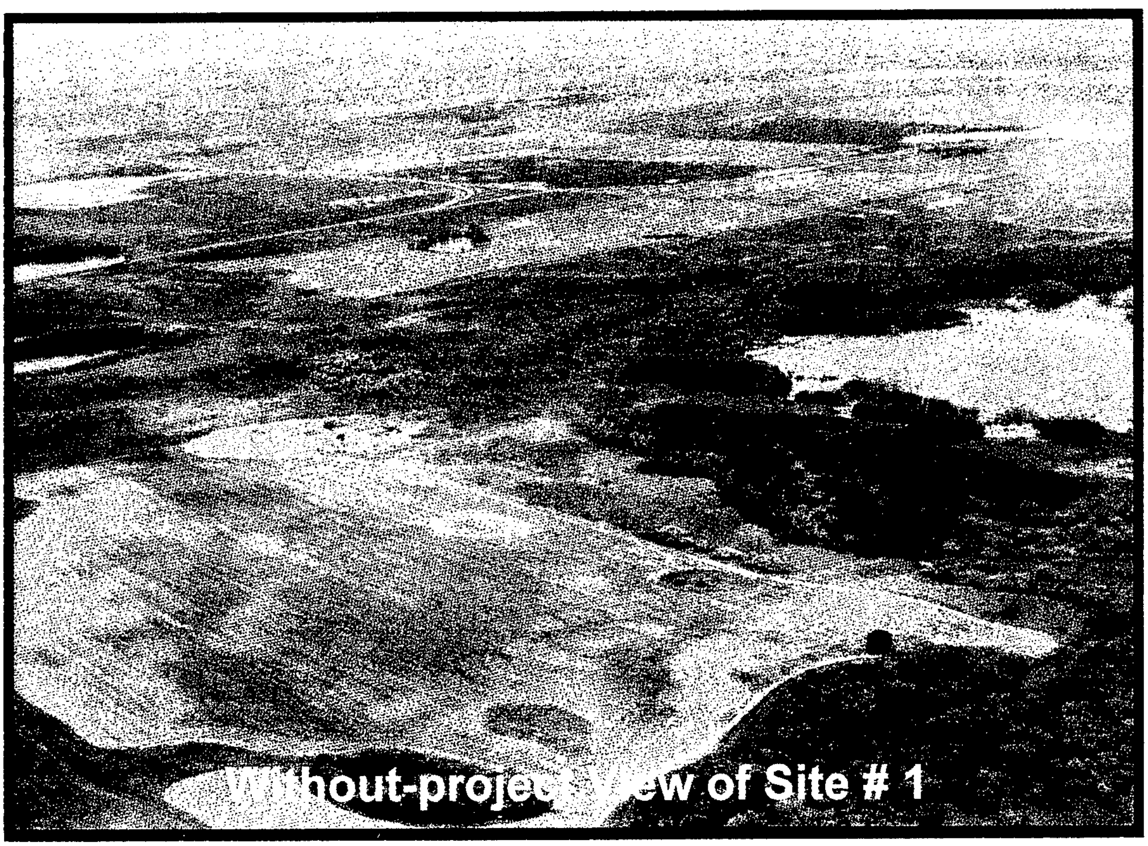
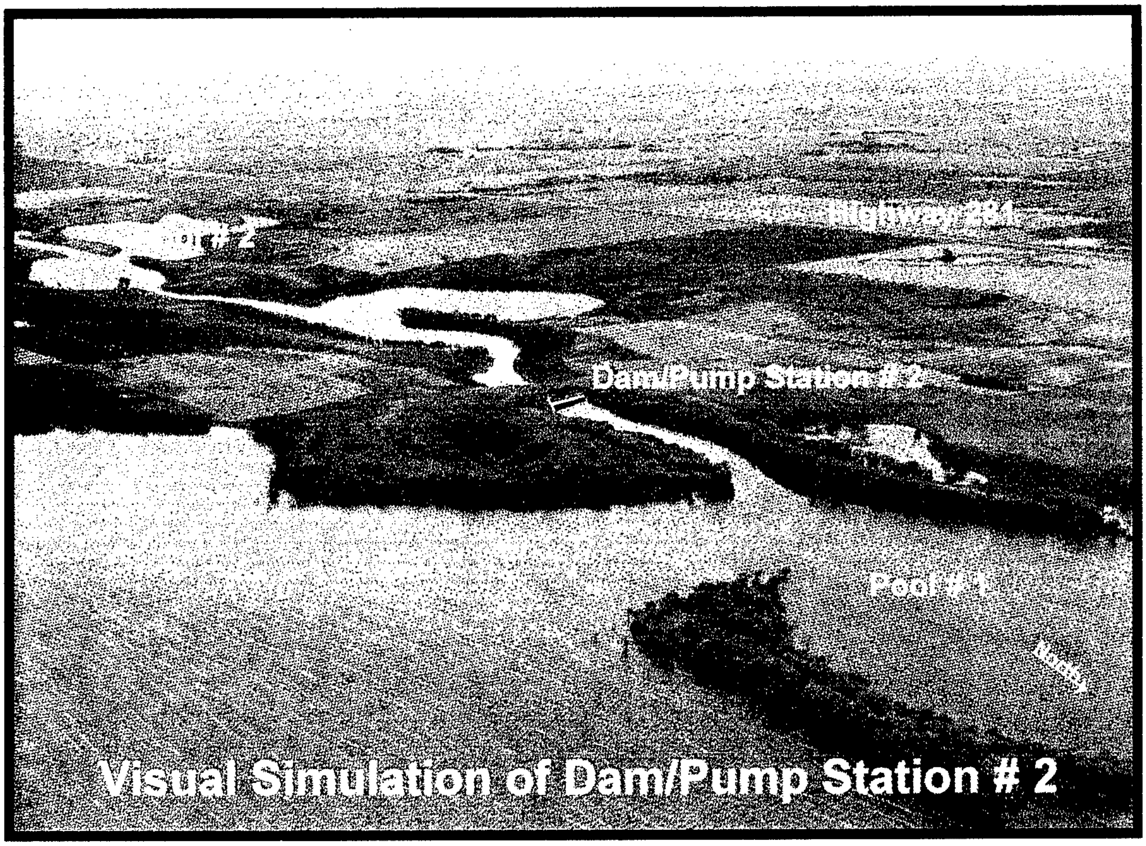
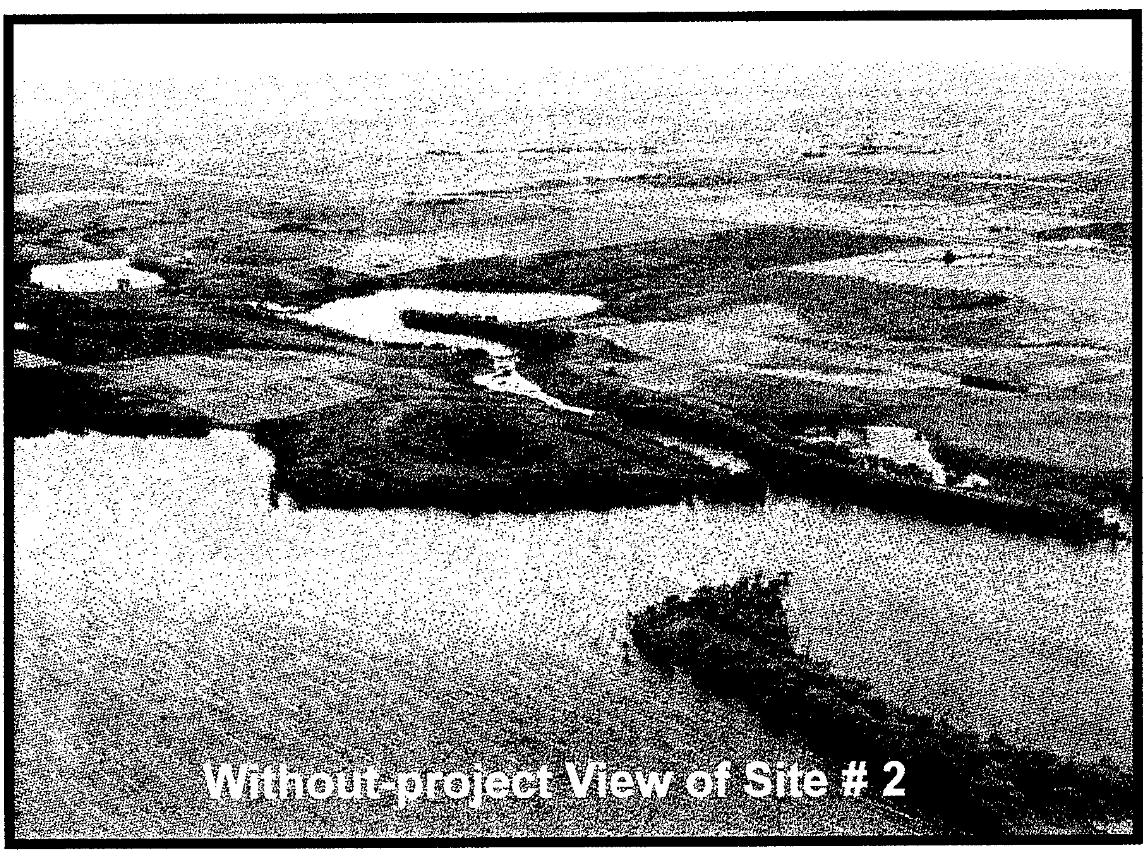

Without-project View of Site # 1

Figure 8

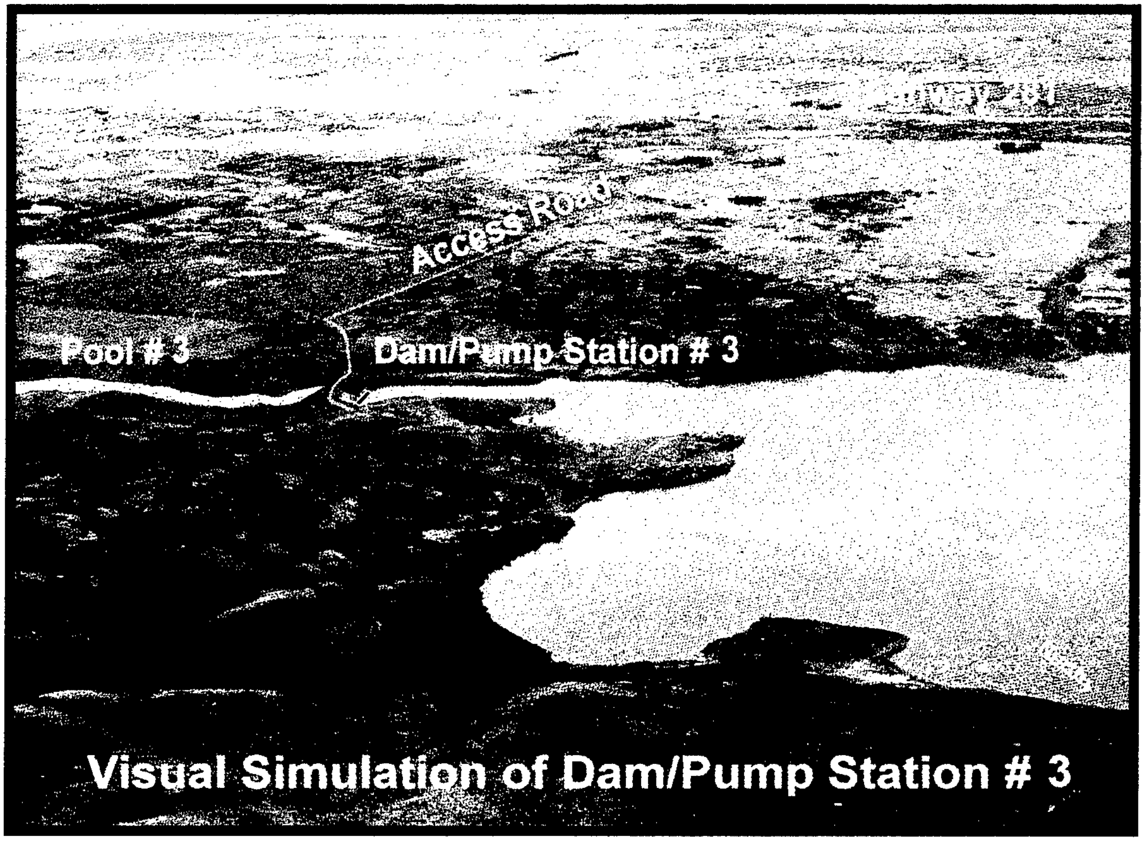


Visual Simulation of Dam/Pump Station # 2



Without-project View of Site # 2

Figure 9



Visual Simulation of Dam/Pump Station # 3

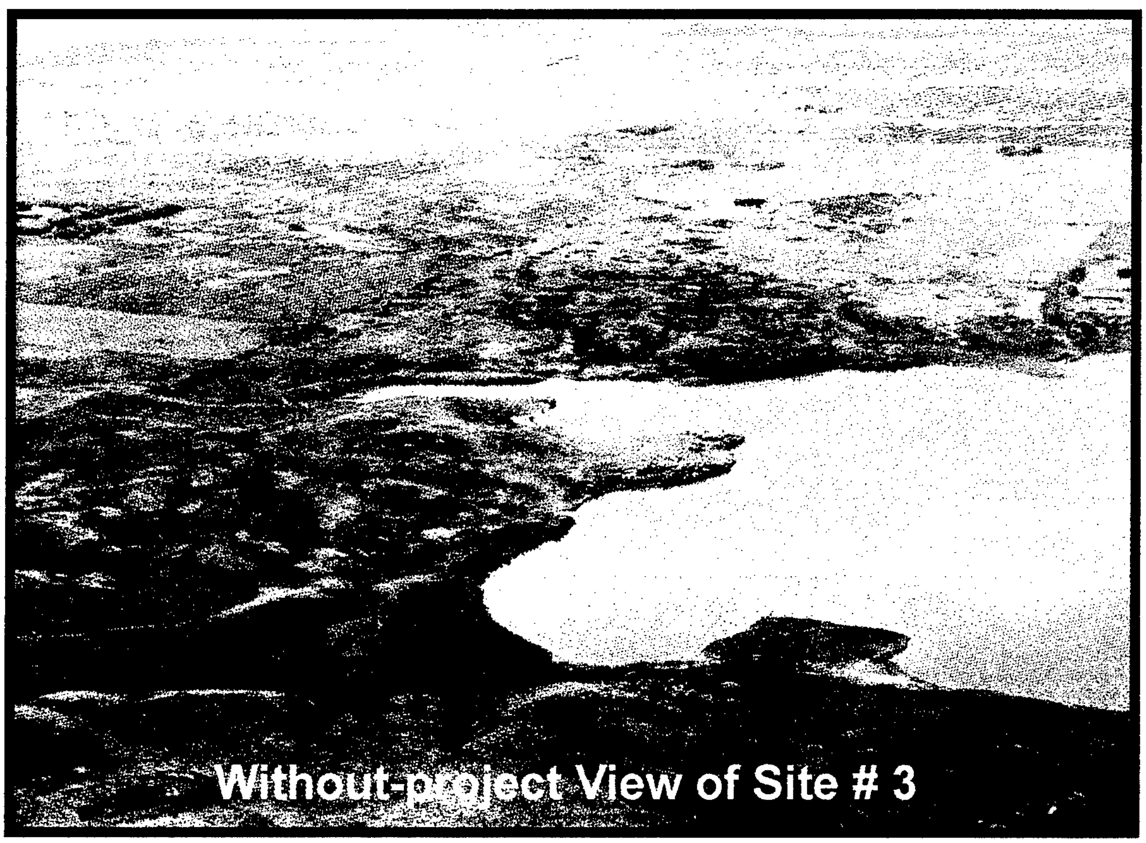
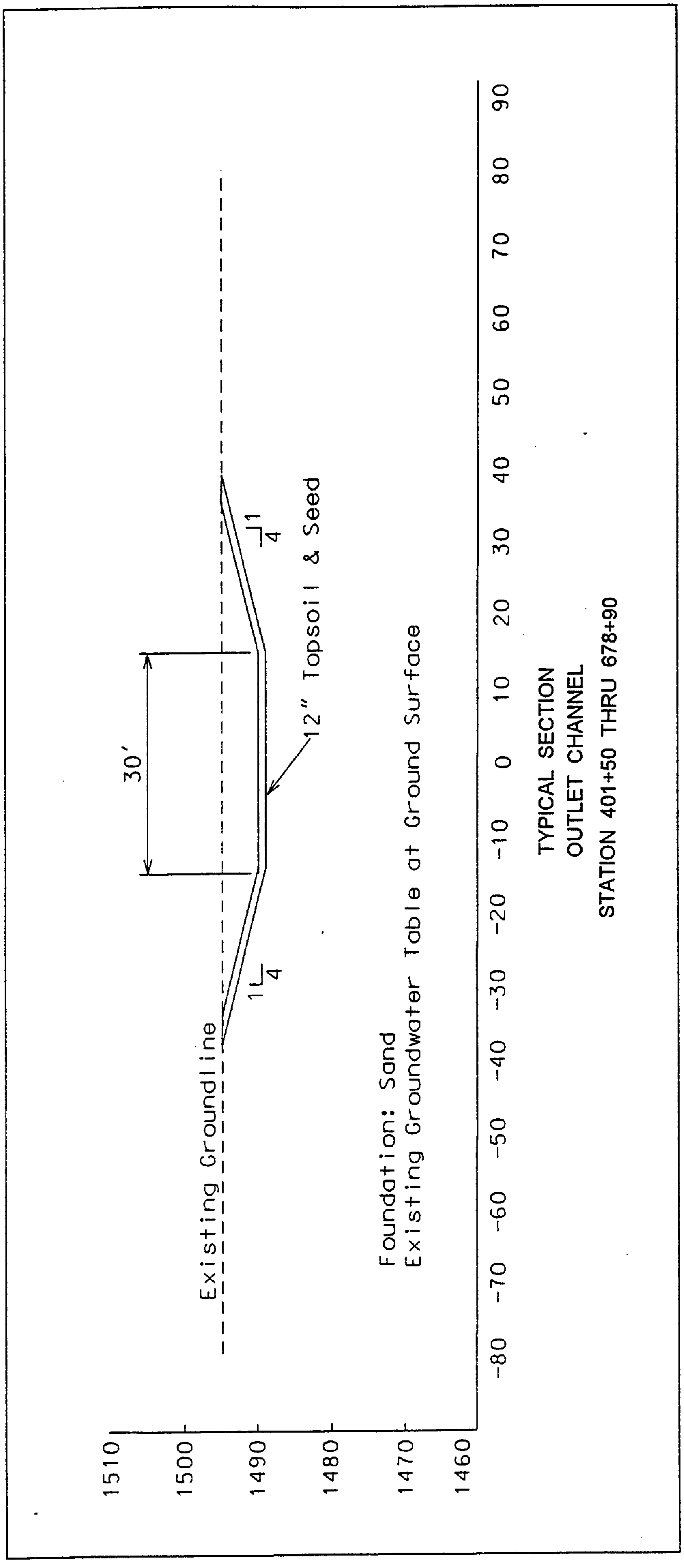
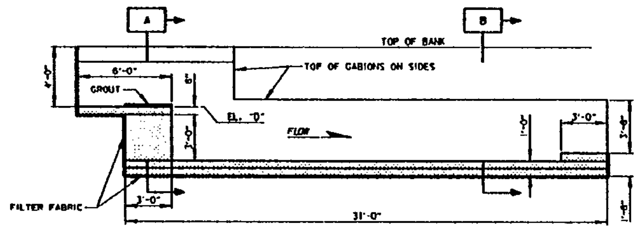

Without-project View of Site # 3

Figure 10



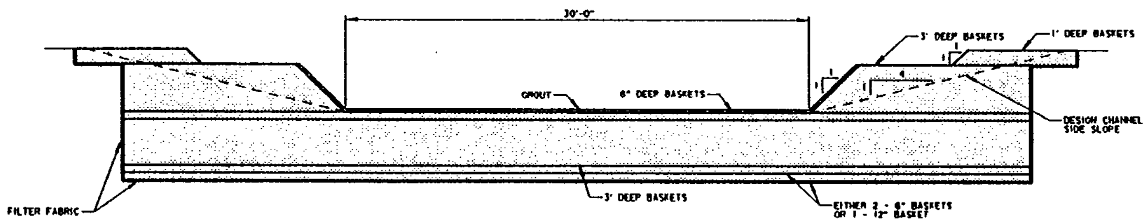
TYPICAL SECTION
OUTLET CHANNEL
STATION 401+50 THRU 678+90
Existing Groundline
30'
12" Topsoil & Seed
1
4
Foundation: Sand
Existing Groundwater Table at Ground Surface
1510
1500
1490
1480
1470
1460
-80
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
80
90

Figure 11

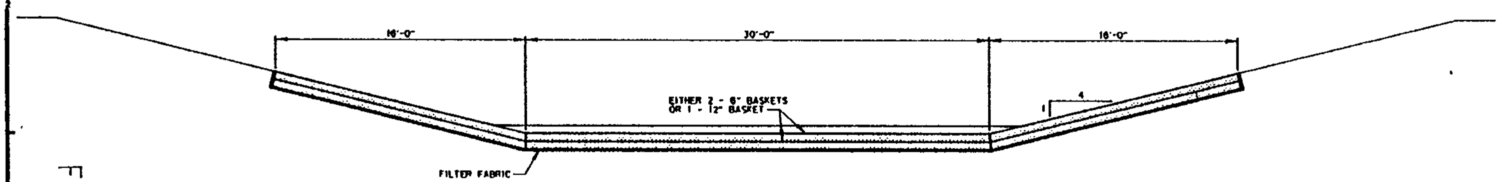


PROFILE
TYPICAL GABION DROP STRUCTURE
SCALE: 1/4" = 1'-0"

STATION	ELEVATION D	NOTES
666+13.08	1416.13	
661+55.91	1419.49	
657+00.74	1422.88	
652+45.58	1426.22	
650+98.53	1429.34	
649+58.81	1432.45	
648+19.09	1435.58	
646+98.03	1438.68	
645+78.14	1441.76	
644+60.24	1444.85	
643+42.35	1447.95	
642+07.30	1451.05	
640+78.20	1454.16	
637+25.32	1457.44	
628+72.08	1461.12	
620+18.80	1464.80	
604+10.38	1469.09	
510+53.00	1479.58	
454+58.04	1487.05	



SECTION A
GABION DROP STRUCTURE
SCALE: 1/4"=1'-0"



SECTION B
GABION DROP STRUCTURE
SCALE: 1/4"=1'-0"

SCALE: 1/4" = 1'-0"

SYMBOL	DESCRIPTION	DATE	APPROVAL

DEPARTMENT OF THE ARMY
ST. PAUL DISTRICT, CORPS OF ENGINEERS
ST. PAUL, MINNESOTA

AE APPROVING OFFICIAL:

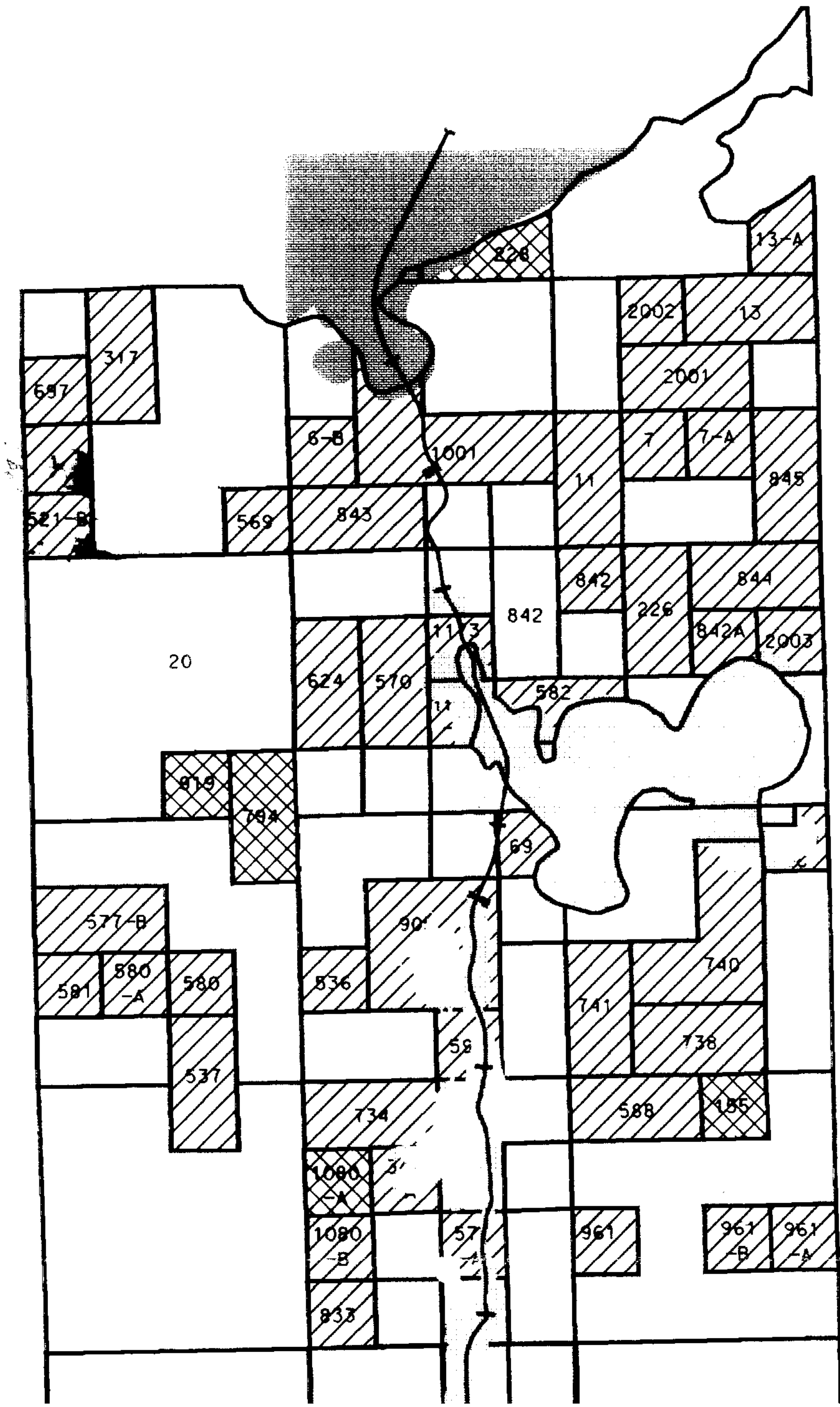
DESIGNED: PDM
CHECKED: BGS
DRAWN: LKT
DESIGNED: PMF
CHECKED: XXX/XXX
DATE: 07-09-98

CONCEPT DESIGN
DEVILS LAKE EMERGENCY OUTLET PLAN
GENERAL INVESTIGATIONS - SHEYENNE RIVER BASIN
DEVILS LAKE — DEVILS LAKE, NORTH DAKOTA
FLOOD CONTROL
GABION DROP STRUCTURES
TYPICAL PROFILE & SECTION

CAD FILE NAME: DVO5RSO5.DGN
SOL. NO.
DRAWING NUMBER: PLATE 7
SHT 7 OF 8

Figure 12

(1)



REAL ESTATE

POOL OPERATING LEVEL

INDIVIDUAL TRUST

TRIBAL TRUST

FEE LAND

ALIGNMENT

DAM / PUMP STATION

TIC MARKS AT 5000 FOOT INTERVALS

N

REAL ESTATE SOURCE DATA:
Bureau of Indian Affairs, Realty Office, Fort Totten N.D.

Produced by St. Paul District, GIS Center, U.S. Army Corps of Engineers, June 1996

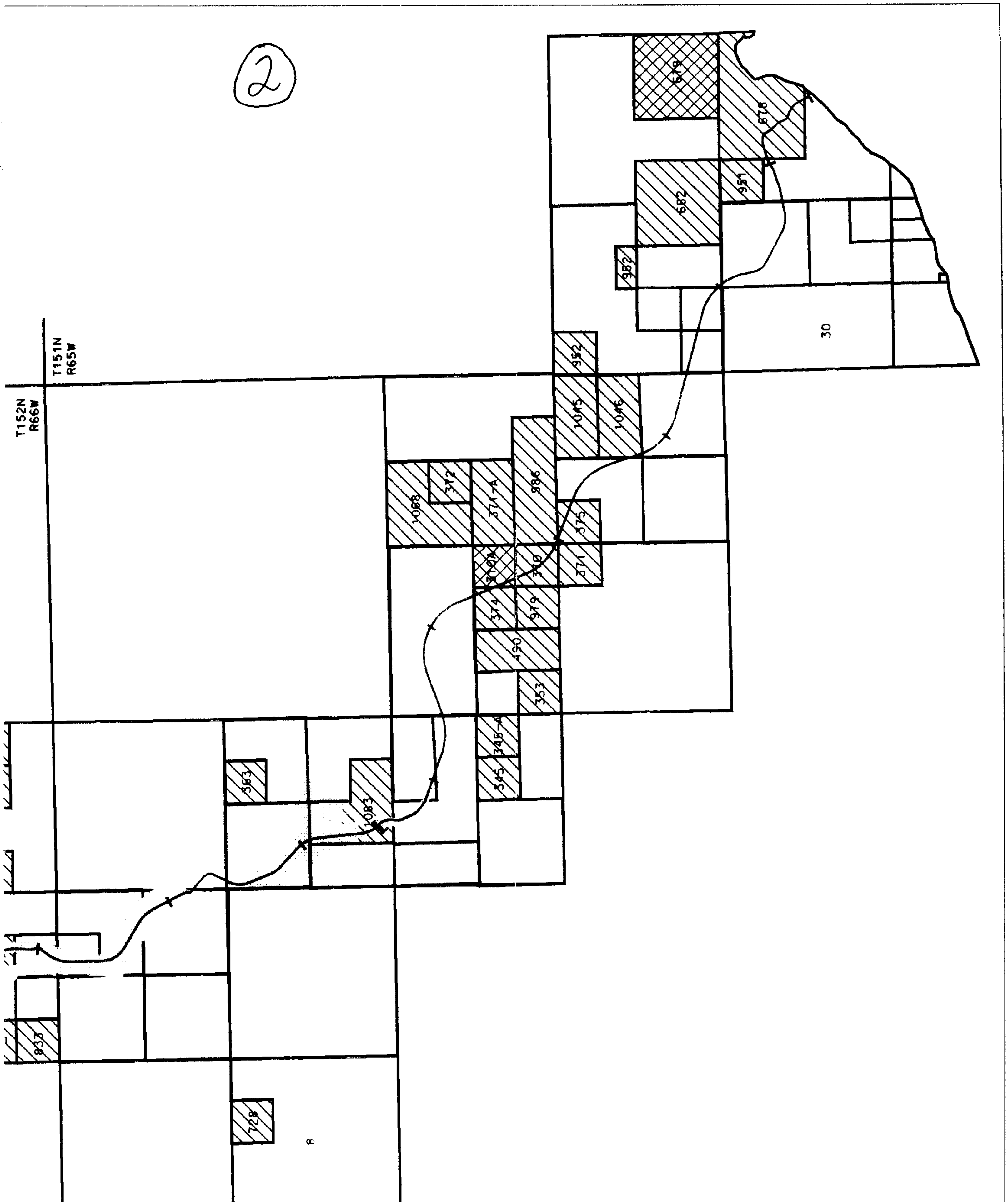
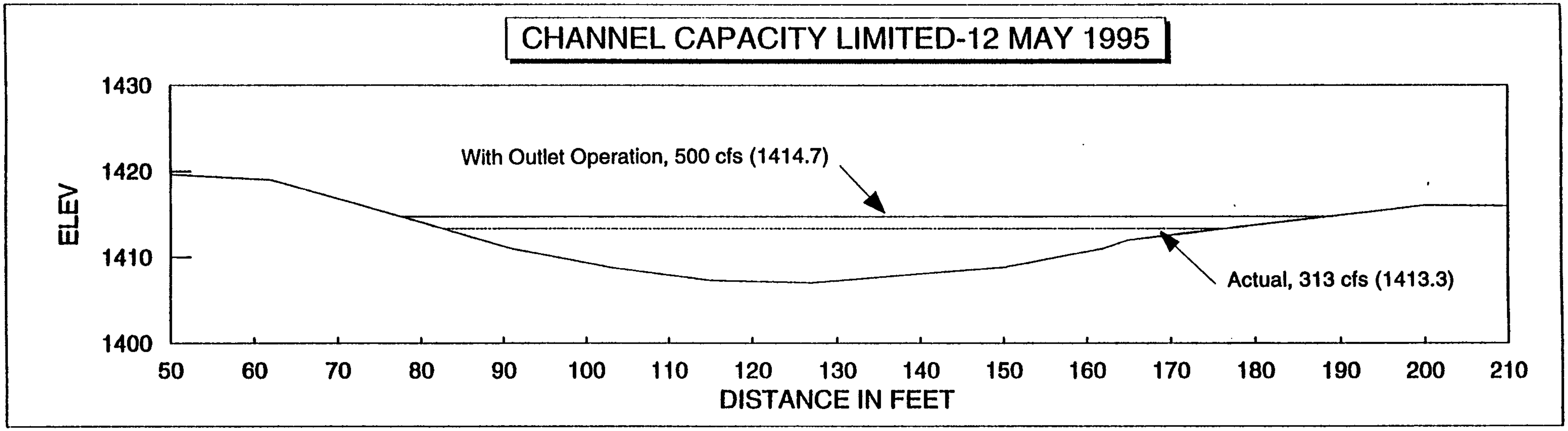

2
T151N
R65W
T152N
R66W
679
678
951
682
952
30
952
1045
1046
986
372
1068
371-A
375
371
370
374
979
490
353
345-A
345
363
1083
833
728
8

Figure 13

Sheyenne River at Diversion Outlet
Section 75 at River Mile 451.1
Surveyed 1944



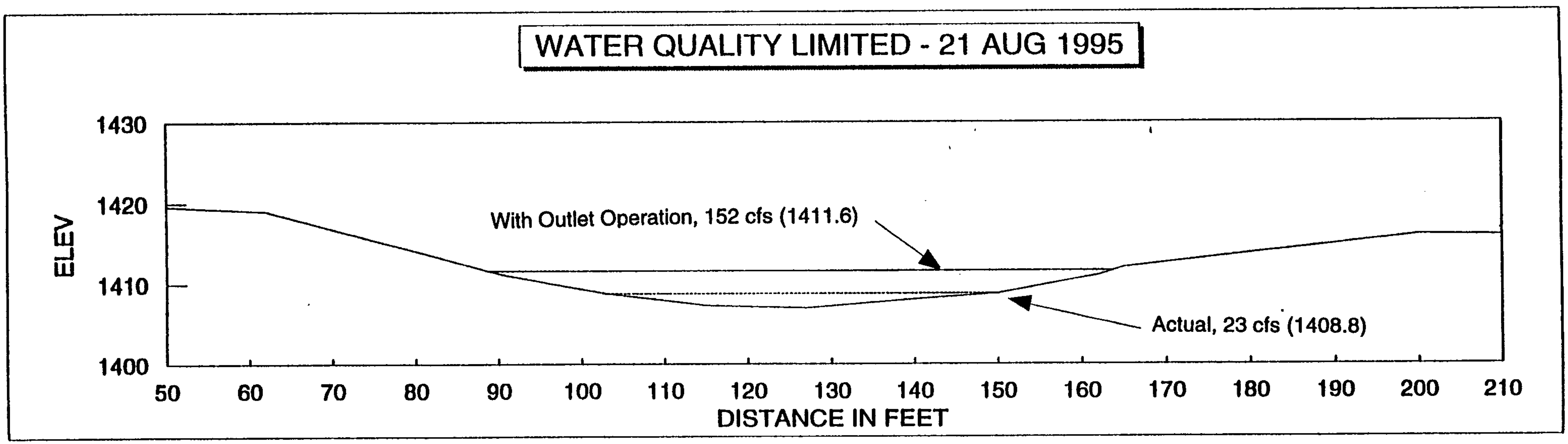
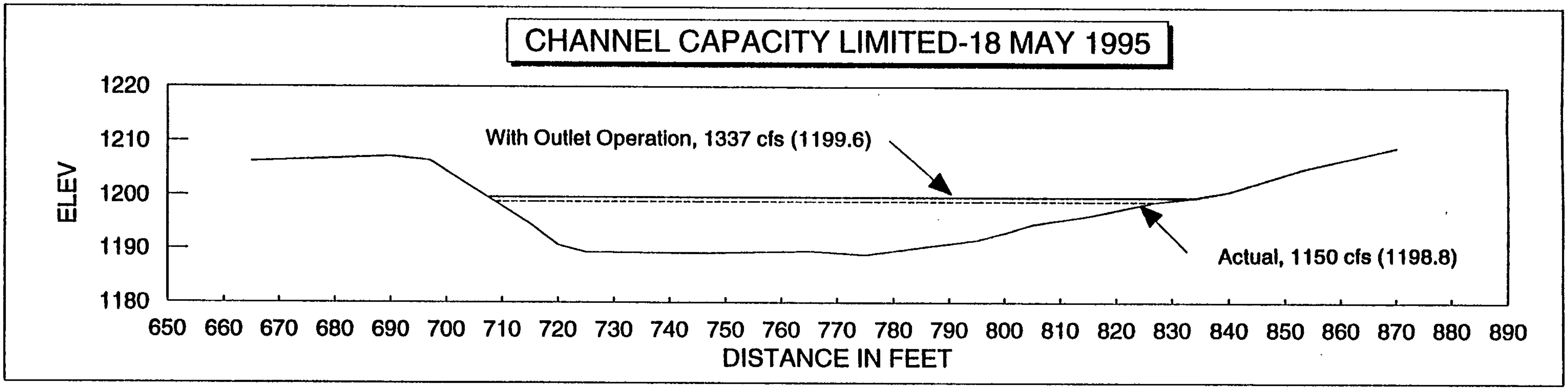


Figure 14

Sheyenne River 3.5 Miles Downstream of Valley City, Section 19



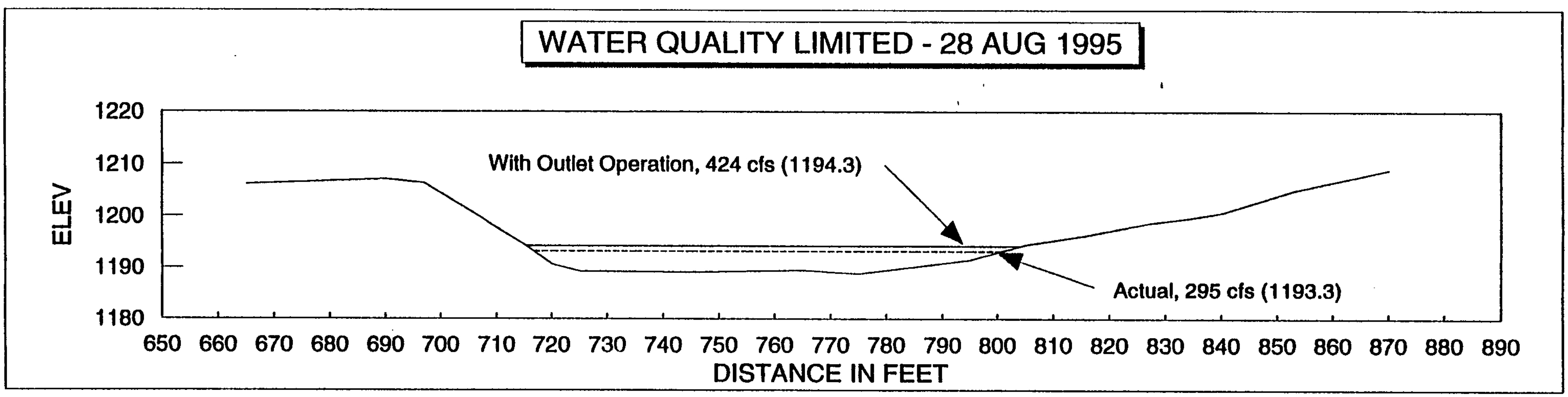


Figure 15

DEVILS LAKE, ND

WITH AND WITHOUT PUMPING ELEV.

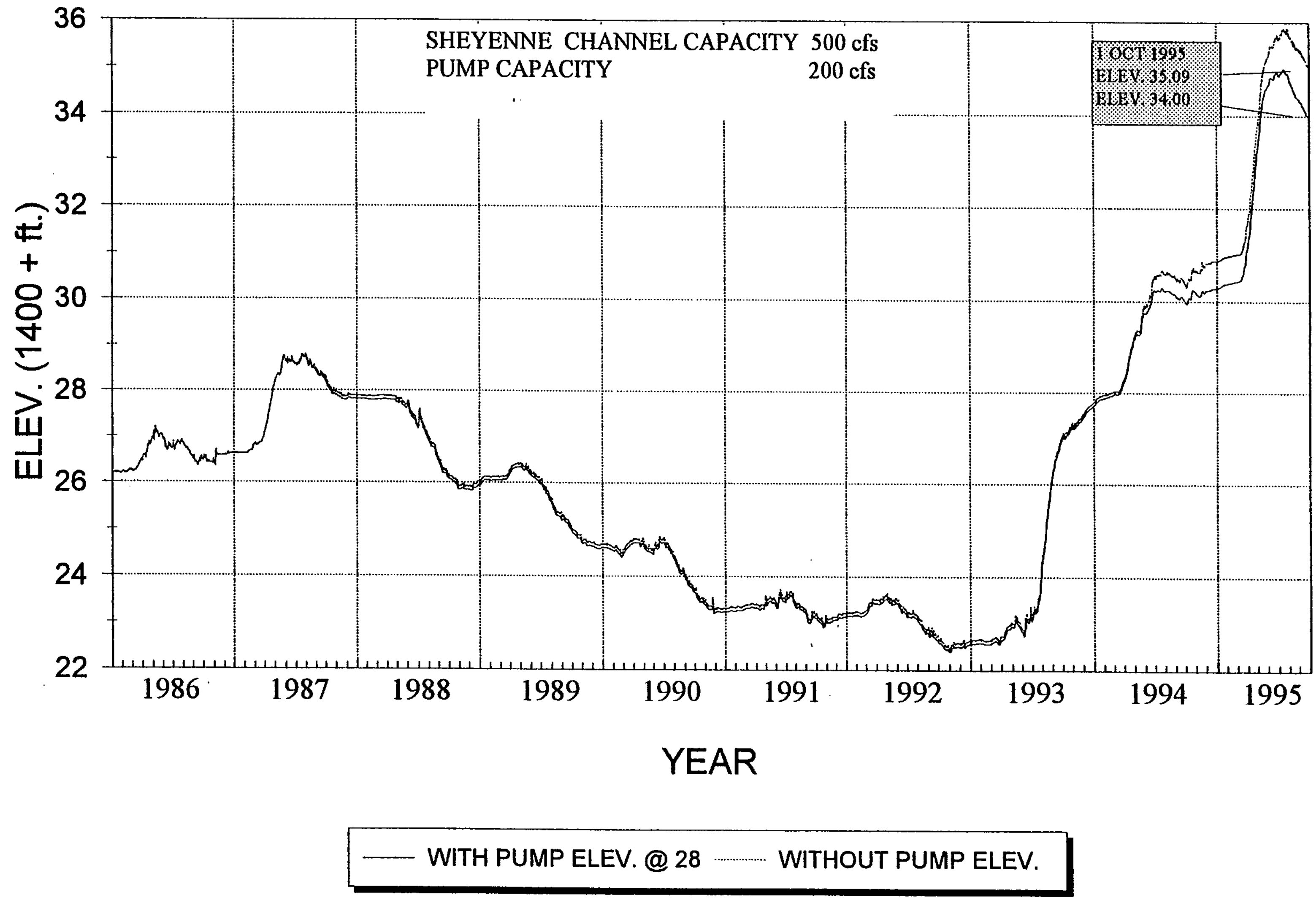


Figure 16

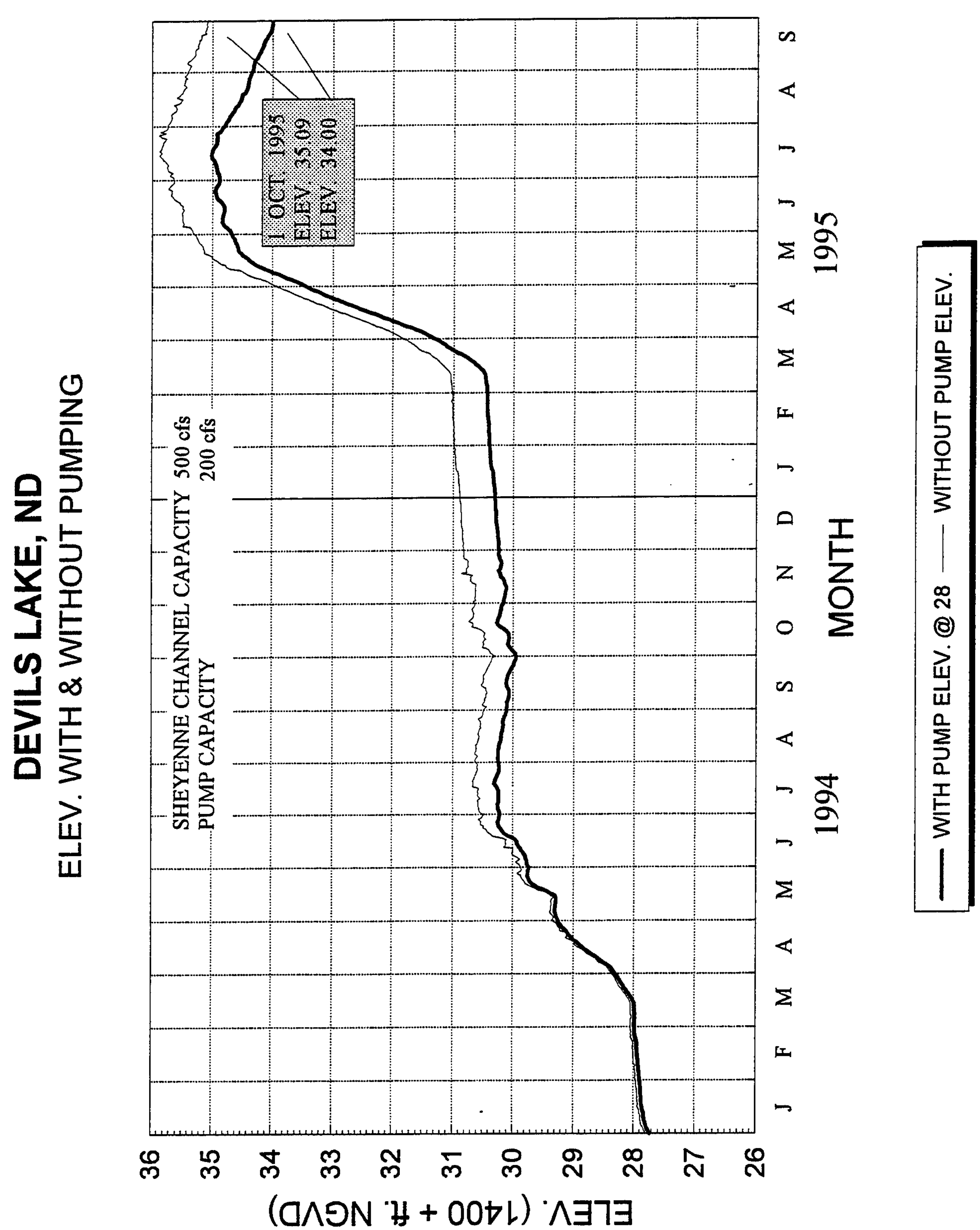
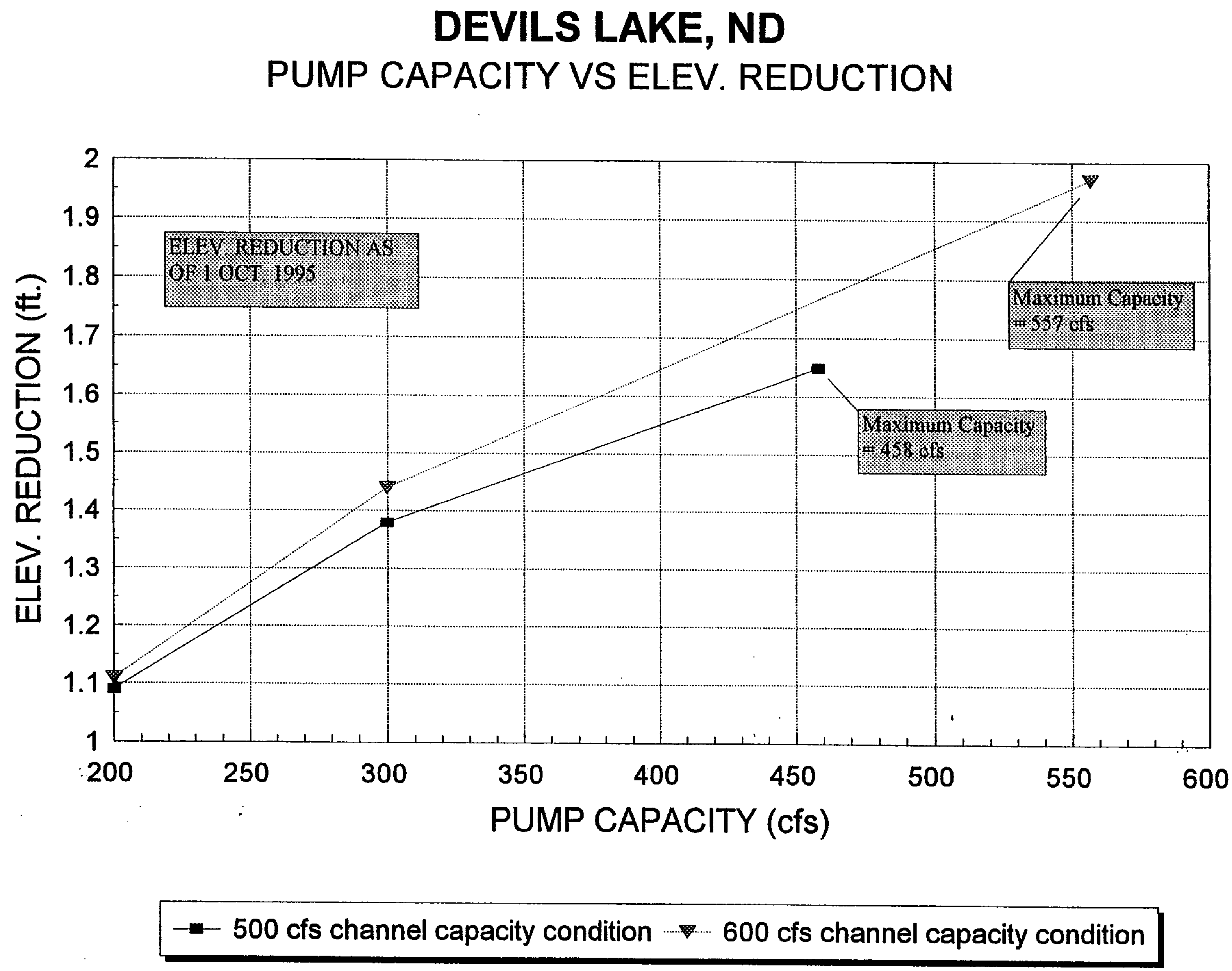

DEVILS LAKE, ND
ELEV. WITH & WITHOUT PUMPING
SHEYENNE CHANNEL CAPACITY 500 cfs
PUMP CAPACITY 200 cfs
1 OCT 1995
ELEV. 35.09
ELEV. 34.00
ELEV. (1400 + ft. NGVD)
36
35
34
33
32
31
30
29
28
27
26
J F M A M J J A S O N D J F M A M J J A S
1994
1995
MONTH
WITH PUMP ELEV. @ 28
WITHOUT PUMP ELEV.

Figure 17



DEVILS LAKE, ND
PUMP CAPACITY VS ELEV. REDUCTION
ELEV. REDUCTION (ft.)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
200
250
300
350
400
450
500
550
600
PUMP CAPACITY (cfs)
ELEV. REDUCTION AS OF 1 OCT. 1995
Maximum Capacity = 557 cfs
Maximum Capacity = 458 cfs
500 cfs channel capacity condition
600 cfs channel capacity condition

Figure 18

DEVILS LAKE, ND; BIG COULEE & WEST BAY
WITH AND WITHOUT PUMPING ELEV.

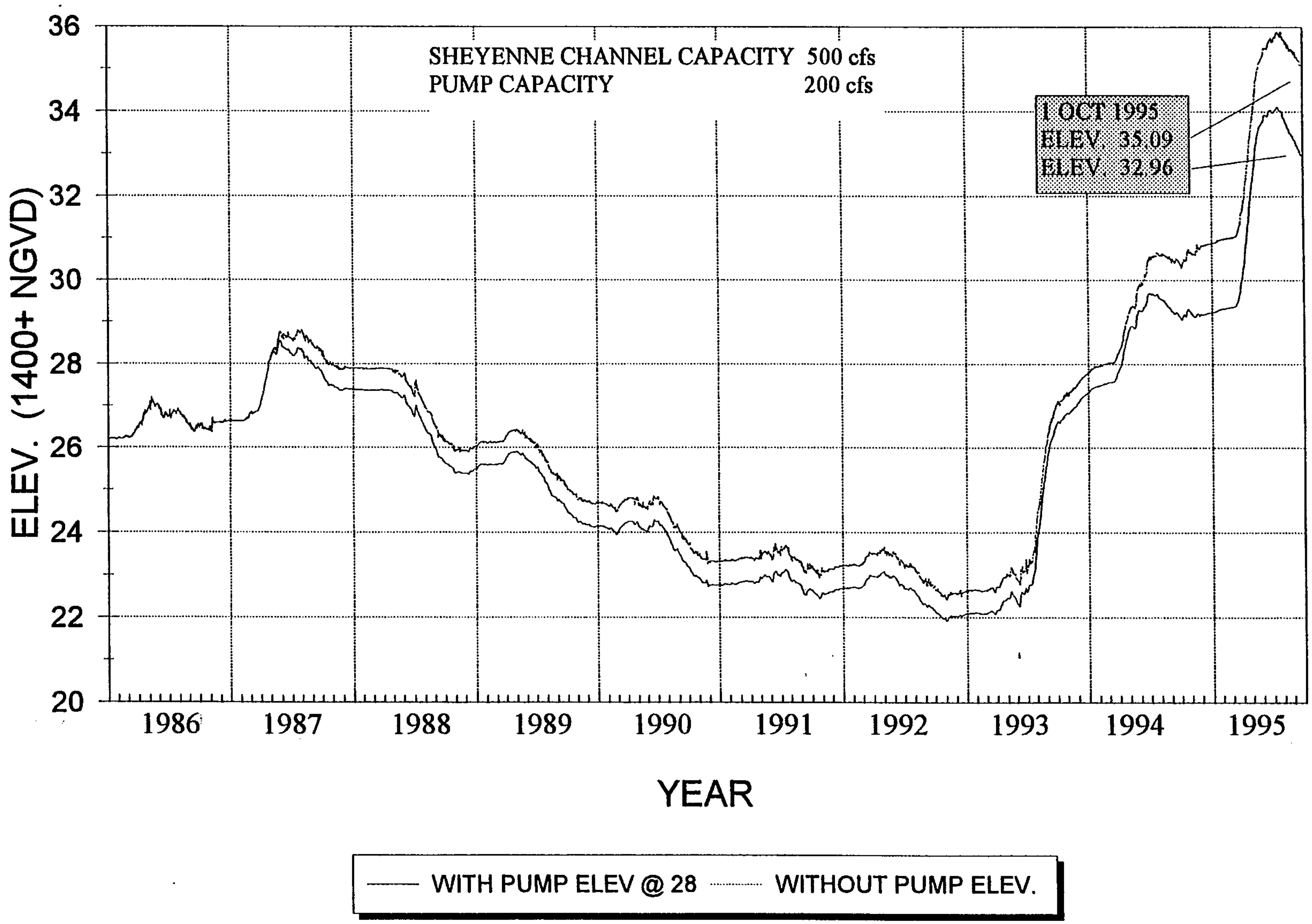
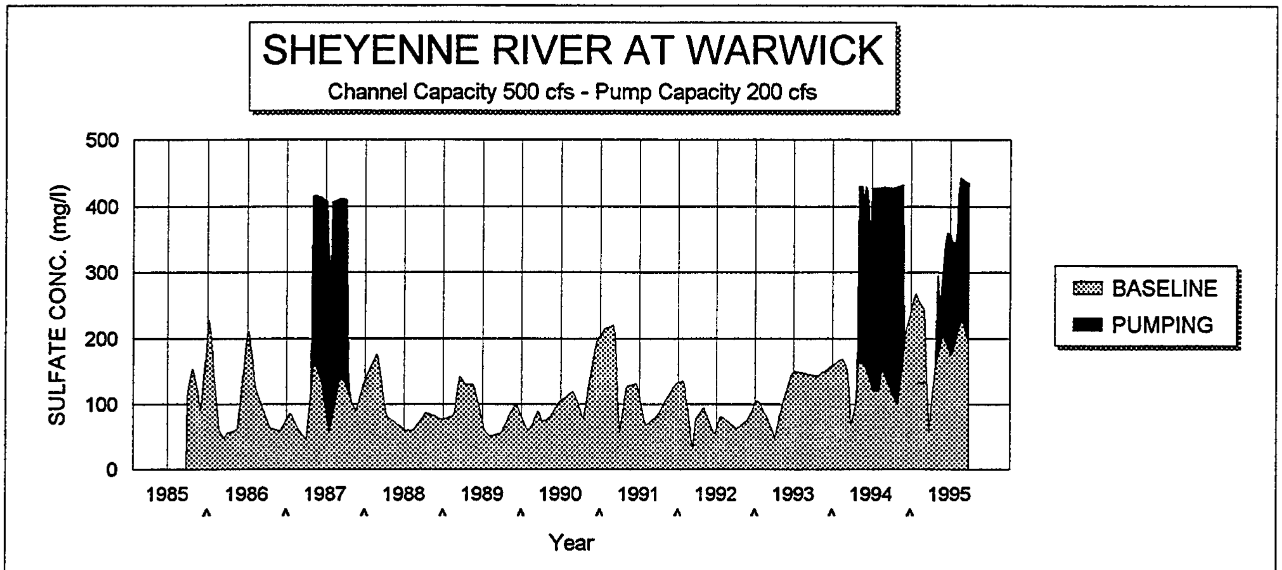
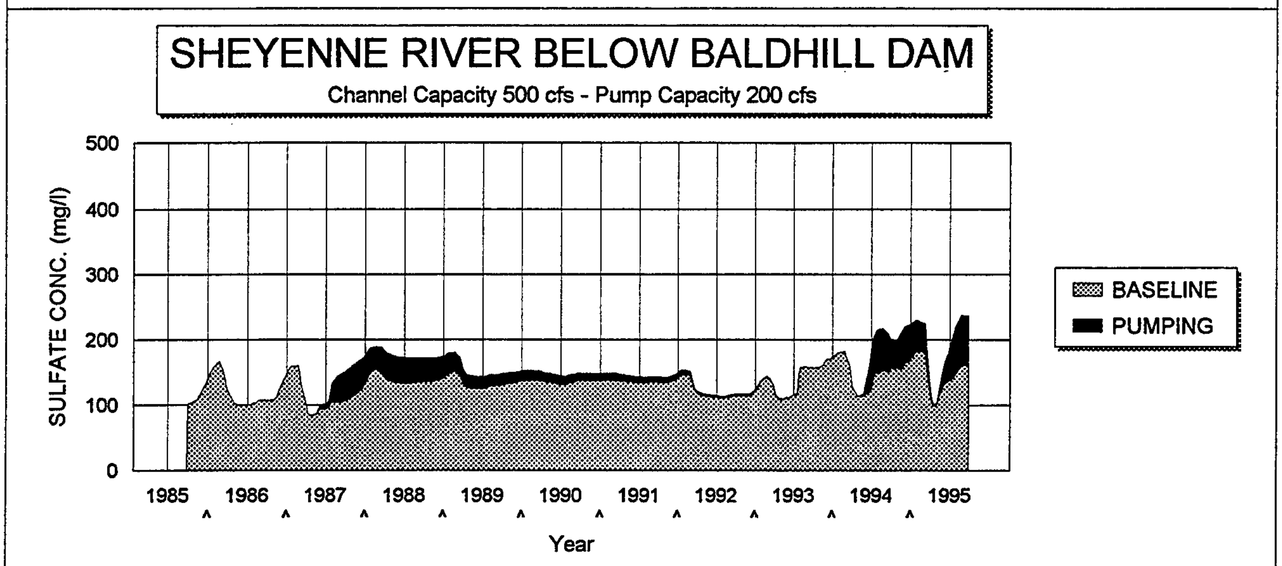


Figure 19


SHEYENNE RIVER AT WARWICK
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
BASELINE
PUMPING


SHEYENNE RIVER BELOW BALDHILL DAM
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
BASELINE
PUMPING

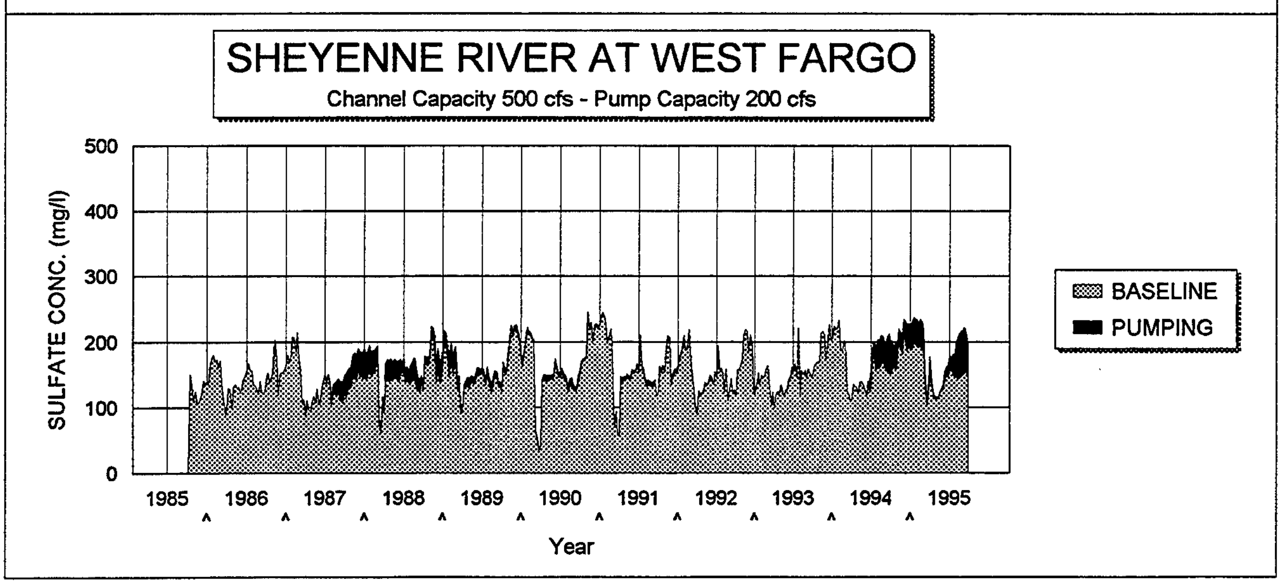
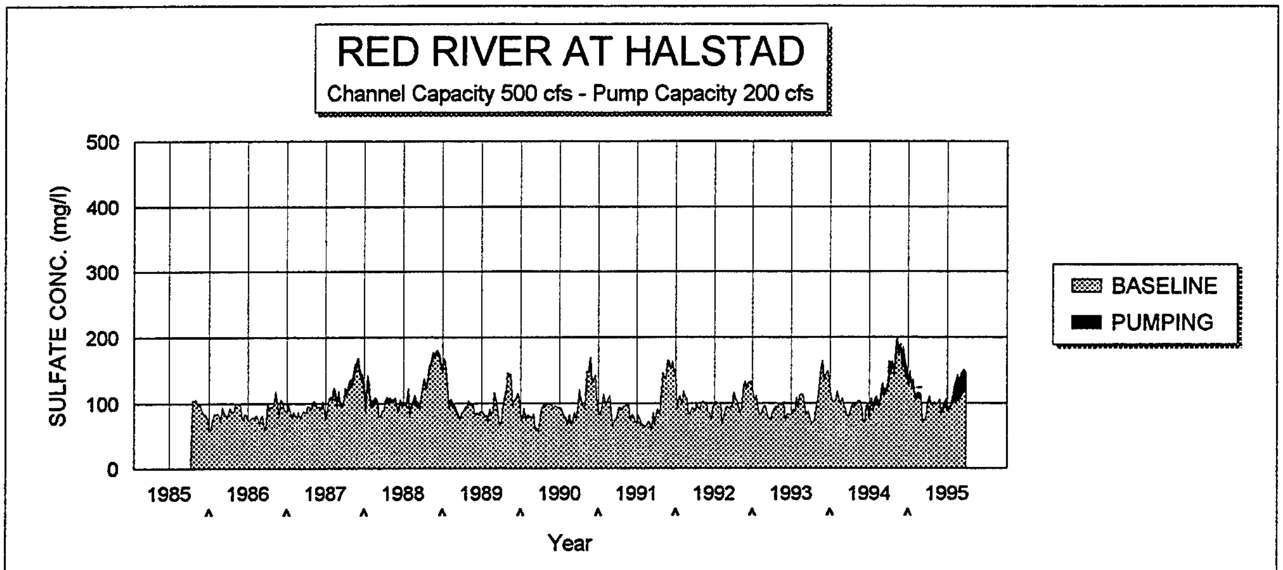
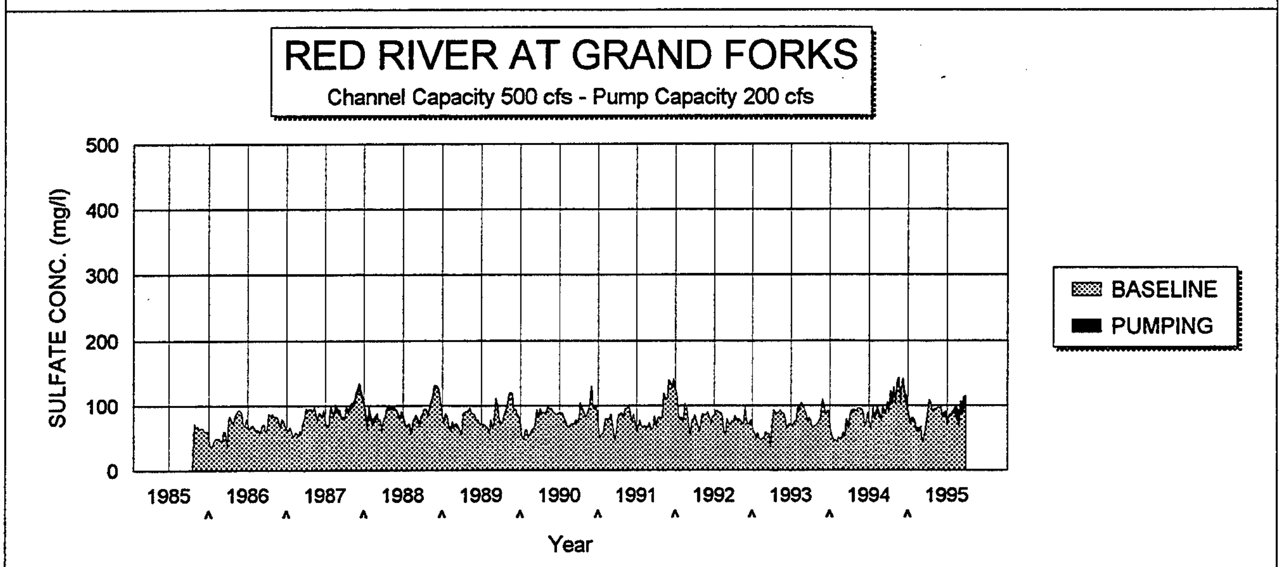

SHEYENNE RIVER AT WEST FARGO
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
500
400
300
200
100
0
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
BASELINE
PUMPING

Figure 20


RED RIVER AT HALSTAD
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
BASELINE
PUMPING


RED RIVER AT GRAND FORKS
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
BASELINE
PUMPING

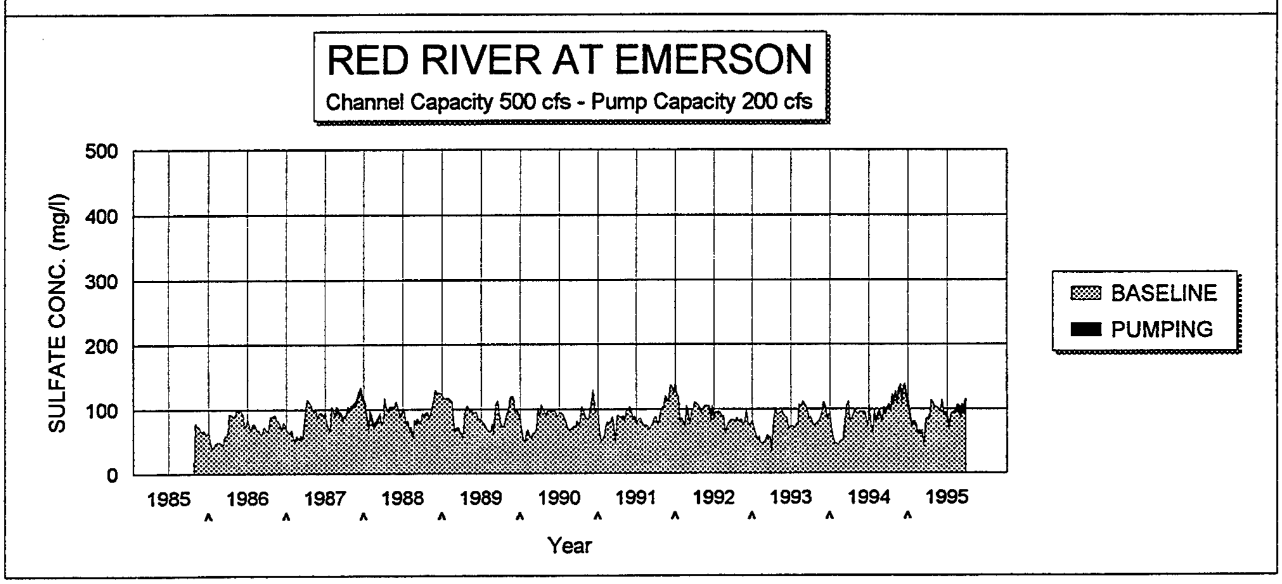
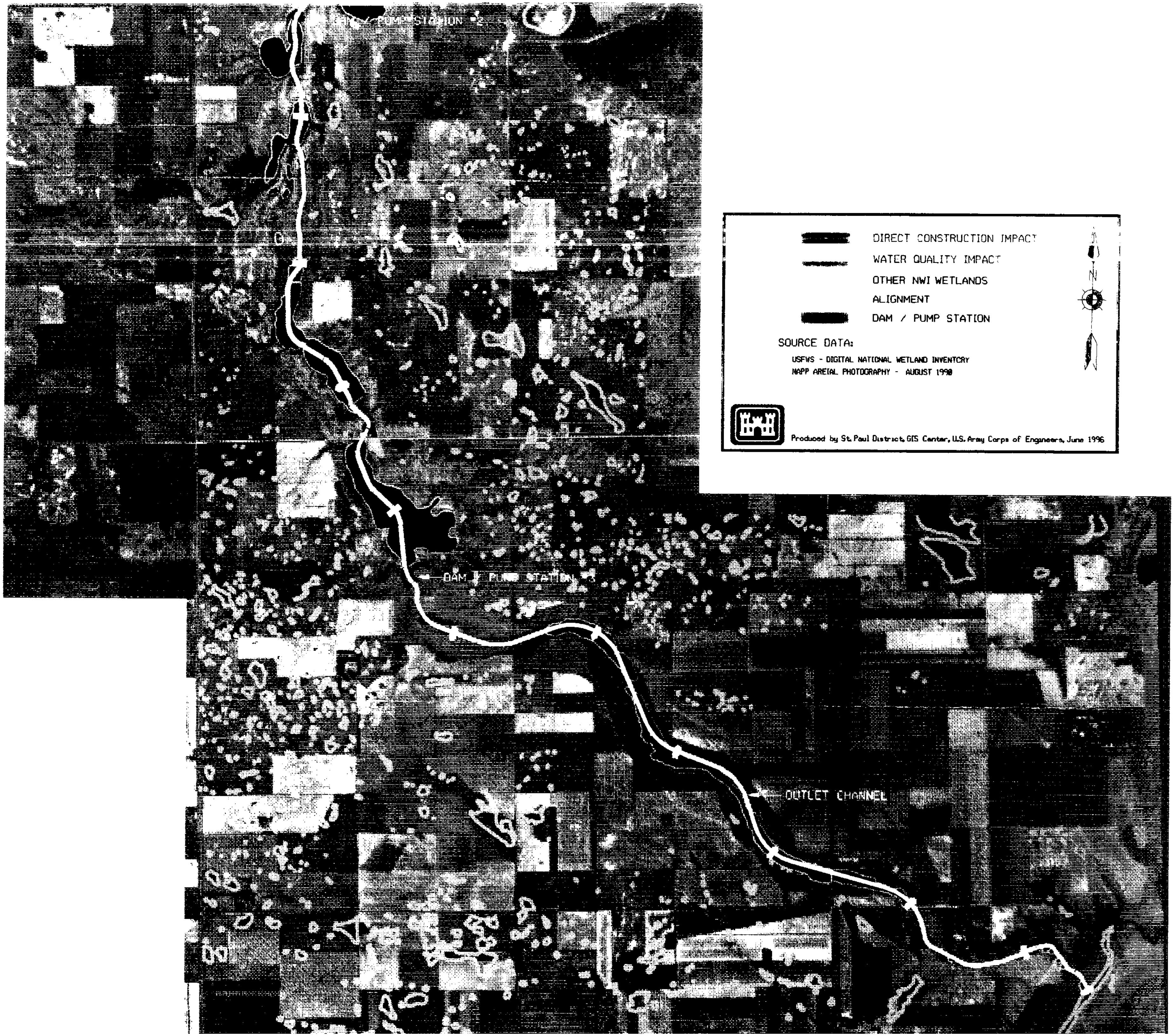

RED RIVER AT EMERSON
Channel Capacity 500 cfs - Pump Capacity 200 cfs
SULFATE CONC. (mg/l)
0
100
200
300
400
500
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
Year
BASELINE
PUMPING

Figure 21

(1)

NWI WETLAND IMPACTS


DAM / PUMP STATION #2
DAM / PUMP STATION #3
OUTLET CHANNEL
DIRECT CONSTRUCTION IMPACT
WATER QUALITY IMPACT
OTHER NWI WETLANDS
ALIGNMENT
DAM / PUMP STATION
N
SOURCE DATA:
USFWS - DIGITAL NATIONAL WETLAND INVENTORY
NAPP AREIAL PHOTOGRAPHY - AUGUST 1990
Produced by St. Paul District, GIS Center, U.S. Army Corps of Engineers, June 1996

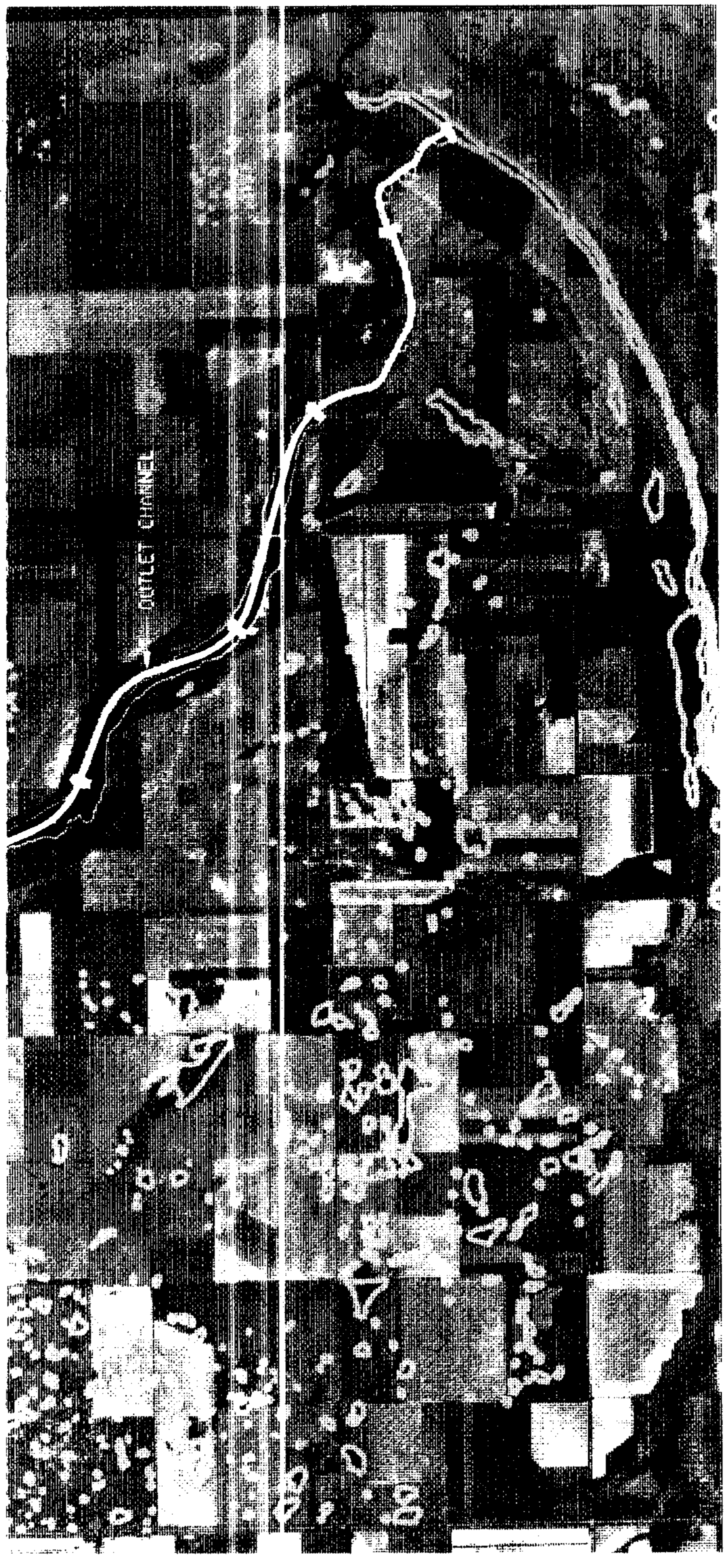


Figure 22